



Leandc series XML configuration manual

Version V21

1	Document	1
2	System configuration	3
2.1	Configuration file leandc.xml	3
2.2	HardwareCfg group node	4
2.2.1	UART element node	5
2.2.2	TCPSERVER element node	7
2.2.3	TCPCLIENT element node	8
2.2.4	UDP element node	9
2.3	CommunicationCfg group node	11
2.3.1	Modbusma element node	12
2.3.2	IEC101ma element node	13
2.3.3	IEC101sl element node	15
2.3.4	IEC103ma element node	17
2.3.5	IEC104ma element node	18
2.3.6	IEC104sl element node	19
2.3.7	IEC104Rsl element node	21
2.3.8	IEC104Csl element node	23
2.3.9	CommsFlags attribute	24
2.4	TraceCfg group and SYSLOGFILE node	25
2.5	ClientFilterCfg group and IPv4 node	26
2.6	SupervisionCfg group node	28
2.6.1	MONRAW element node	29
2.6.2	MONCOMP element node	30
2.6.3	REDIRECT element node	31
2.6.4	OVERRIDE element node	32
3	IEC60870-5-101 Slave configuration	33
3.1	ProtocolCfg group node	34
3.1.1	XMLSettings attributes	35
3.1.2	LinkSettings attributes	36
3.1.3	CommsSettings attributes	37
3.1.4	ASDUSettings attributes	38
3.1.5	Timeouts attributes	40
3.1.6	TimeSettings attributes	41
3.1.7	Periodic attributes	42
3.1.8	BufferSizes attributes	43
4	IEC60870-5-104 Slave configuration	45
4.1	ProtocolCfg group node	46
4.1.1	XMLSettings attributes	47
4.1.2	TransportSettings attributes	48

4.1.3	CommsSettings attributes	49
4.1.4	ASDUSettings attributes	50
4.1.5	Timeouts attributes	52
4.1.6	TimeSettings attributes	53
4.1.7	Periodic attributes	54
4.1.8	BufferSizes attributes	55
4.1.9	Miscellaneous attributes	56
5	IEC60870-5-101/104 Slave IO object table	57
5.1	DITable group and DI node	58
5.1.1	DI attributes	59
5.1.2	DI.qualifier	60
5.1.3	DI.TypeID	61
5.1.4	DI Service Indexes	62
5.2	AITable group and AI node	63
5.2.1	AI attributes	64
5.2.2	AI.qualifier	66
5.2.3	AI.TypeID	67
5.3	DI/AI.GroupMask	69
5.4	DOTable group and DO node	71
5.4.1	DO attributes	72
5.4.2	DO.qualifier	74
5.4.3	DO.TypeID	75
5.4.4	DO Service Indexes	76
5.5	AOTable group and AO node	77
5.5.1	AO attributes	78
5.5.2	AO.qualifier	79
5.5.3	AO.TypeID	80
5.6	DO/AO.Policy	81
5.7	AUTOCfg group and AUTO node	82
6	IEC60870-5-101 Master configuration	85
6.1	ProtocolCfg group node	86
6.1.1	XMLSettings attributes	87
6.1.2	LinkSettings attributes	88
6.1.3	CommsSettings attributes	89
6.1.4	ASDUSettings attributes	91
6.1.5	Timeouts attributes	93
6.1.6	TimeSettings attributes	94
6.1.7	Broadcast attributes	95
6.1.8	Periodic attributes	96
6.1.9	BufferSizes attributes	97
7	IEC60870-5-104 Master configuration	99
7.1	ProtocolCfg group node	100
7.1.1	XMLSettings attributes	101
7.1.2	TransportSettings attributes	102
7.1.3	CommsSettings attributes	103
7.1.4	ASDUSettings attributes	104
7.1.5	Timeouts attributes	106
7.1.6	TimeSettings attributes	107
7.1.7	Broadcast attributes	108
7.1.8	Periodic attributes	109
7.1.9	BufferSizes attributes	110
8	IEC60870-5-101/104 Master IO object table	111
8.1	DITable group and DI node	112
8.1.1	DI attributes	113
8.1.2	DI.qualifier	114

8.1.3	DI.TypeID	115
8.2	AI Table group and AI node	116
8.2.1	AI attributes	117
8.2.2	AI.qualifier	119
8.2.3	AI.TypeID	120
8.3	DO Table group and DO node	122
8.3.1	DO attributes	123
8.3.2	DO.qualifier	124
8.3.3	DO.TypeID	125
8.3.4	DO.QOC	126
8.4	AO Table group and AO node	127
8.4.1	AO attributes	128
8.4.2	AO.qualifier	129
8.4.3	AO.TypeID	130
9	IEC60870-5-103 Master configuration	131
9.1	ProtocolCfg group node	132
9.1.1	CommsSettings attributes	133
9.1.2	ASDUSettings attributes	135
9.1.3	Timeouts attributes	136
9.1.4	TimeSettings attributes	137
9.1.5	Broadcast attributes	138
9.1.6	Periodic attributes	139
9.2	DI Table group and DI node	140
9.2.1	DI attributes	141
9.2.2	DI.qualifier	142
9.3	AI Table group and AI node	143
9.3.1	AI attributes	144
9.3.2	AI.qualifier	147
9.4	DO Table group and DO node	148
9.4.1	DO attributes	149
9.4.2	DO.qualifier	150
10	Modbus Master configuration	151
10.1	ProtocolCfg group node	152
10.1.1	LinkSettings attributes	153
10.1.2	CommsSettings attributes	154
10.1.3	Hardcoded attributes	155
10.1.4	Hardcoded types	156
10.1.5	AppSettings attributes	157
10.1.6	Timeouts attributes	158
10.2	DI Table group and DI node	159
10.2.1	DI attributes	160
10.3	AI Table group and AI node	161
10.3.1	AI attributes	162
10.4	DO Table group and DO node	164
10.4.1	DO attributes	165
11	Logfile configuration file lelogger.xml	167
11.1	CommsCfg group and LOGGER; HWLOG nodes	168
11.1.1	LOGGER and HWLOG attributes	169
11.1.2	LOGGER.LogFlags	170
11.2	EventCfg group and EVENTLOG; HWEVENTLOG node	171
11.2.1	EVENTLOG and HWEVENTLOG attributes	172
11.2.2	EVENTLOG.LogFlags	173
11.2.3	LOGGER.Mode and EVENTLOG.Mode	174
12	Configuration version control	175
12.1	VersionControl attributes	176

13 Annexes	177
13.1 Analog value processing	177
13.1.1 AI scaling without StartOffset enabled	178
13.1.2 AI scaling with StartOffset enabled	181
13.1.3 Received AI processing	183
13.1.4 0-20mA transducers	186
13.1.5 4-20mA transducers	187
13.1.6 Special transducers	188
13.2 Time Zone specification	190
14 Document version control	191

Abbreviations used in this document are listed in the following table.

Table 1.1 Abbreviations

Abbreviation	Description
AI	Analog Input
AO	Analog Output
APCI	Application Protocol Control Interface
APDU	Application Protocol Data Unit
ASDU	Application Service Data Unit
CAA	Common address of ASDU
COT	Cause of transmission
DI	Digital Input
DO	Digital Output
DST	Daylight Saving Time
IANA	Internet Assigned Numbers Authority
IO	Input/Output
IP	Internet Protocol
IOA	Information Object Address
LRU	Logical Remote Unit
PID	Running Process Identifier
OS	Operating System
SSH	Secure shell
TCP	Transmission Control Protocol
UDP	User Datagram Protocol

Colored text:

Tip:

Notes in green provides additional information

Important:

Note in orange regarded as warning

Note:

Highlighted text refers to definitions used in communication standards

Dark blue used to highlight XML nodes and attributes

Underlined links to definitions

System configuration

2.1 Configuration file leandc.xml

XML configuration file **leandc.xml** contains overall system settings of the leandc firmware and it is the first file loaded upon system startup. The configuration file name is fixed, it must be stored in the same directory as leandc firmware and its path can't be changed. If 'leandc.xml' file is not found upon leandc firmware startup, firmware terminates with an error message indicating the cause of fail.

leandc.xml configuration file consists of a root object node [MainConfig](#) which has 3 mandatory child group object nodes [VersionControl](#); [HardwareCfg](#) and [CommunicationCfg](#) and 3 optional child group object nodes [TraceCfg](#) and [ClientFilterCfg](#) and [SupervisionCfg](#), please see the sample below.

Tip:

Node names are not case sensitive.

```
<MainConfig xmlns="http://www.londelec.com/xmlschemas/leandc/main" ... version="2.00">
  <VersionControl conf="4" date="2014-01-18" time="10:08:09"/>
  <HardwareCfg>
    <UART Index="1" Devpath="/dev/ttyS0" Baudrate="9600" DataBits="8" Parity="E" ... />
    ...
  </HardwareCfg>
  <CommunicationCfg>
    <IEC101ma Index="10" HWIndex="100" XMLpath="IEC101ma_test.xml" LinkAddr="1"/>
    ...
  </CommunicationCfg>
  <TraceCfg>
    <SYSLOGFILE LogFlags="0x00" Mode="0" HourLimit="0" Logfile="Syslog/syslog"/>
    ...
  </TraceCfg>
  <ClientFilterCfg>
    <IPv4 FilterID="1" ClientIPAddr="10.19.0.21" Mask="32"/>
    ...
  </ClientFilterCfg>
  <SupervisionCfg>
    <MONRAW SrcHWIndex="11" DstHWIndex="10" SrvHWIndex="9"/>
    ...
  </SupervisionCfg>
</MainConfig>
```

2.2 HardwareCfg group node

[HardwareCfg](#) group node is used to configure physical interfaces such as serial ports and network sockets. Each physical interface (e.g. Serial port) or socket (e.g. TCP server) will have XML element node (e.g. [UART](#); [TCPSEVER](#); [TCPCLIENT](#) or [UDP](#)) with XML attributes defining its settings. [HardwareCfg](#) group node can have multiple child element nodes as shown in the sample below.

```
<HardwareCfg>
  <UART Index="1" Devpath="/dev/ttyUSB0" Baudrate="9600"... />
  <UART Index="2" Devpath="/dev/ttyUSB1" Baudrate="9600"... />
  <TCPSEVER Index="33" ServerIPAddr="127.0.0.1" Port="2404"... />
  <TCPCLIENT Index="44" ServerIPAddr="127.0.0.1" Port="2404"... />
  <UDP Index="55" RemoteIPAddr="127.0.0.1" RemotePort="64950"... />
</HardwareCfg>
```

Important:

There must be one and only one [HardwareCfg](#) group node specified under root object node [MainConfig](#) in configuration file 'leandc.xml'.

It is essential to keep element nodes in the listed order otherwise it will affect the XML file validation.

2.2.1 UART element node

Settings of the serial ports are configured using [UART](#) element node. Please see sample [UART](#) element node and the table listing all available attributes below.

```
<UART      Index="1"
  Devpath="/dev/ttyUSB0"
  Baudrate="9600"
  DataBits="8"
  Parity="E"
  StopBits="1"
  Timeout="3"
  TxDelay="0.5"
  CtrlRdTimer="0.5"
  CtrlRdDebounce="8"
  Name="COM1"/>
```

Table 2.1 Leandc UART node

Attribute	Values or range	Description
Index	1...254	Index is a unique identifier of the hardware node. It is used as a reference to link a communication protocol instance to this node. Indexes don't have to be in a sequential order.
Devpath*	Max 100 chars	Path of the UART device in the Linux operating system. All serial ports are normally located under ' /dev ' folder. Inbuilt serial ports are referenced as ' /dev/ttyS0 '; ' /dev/ttyS1 ' and USB to Serial adapters are referenced as ' /dev/ttyUSB0 '; ' /dev/ttyUSB0 '; etc Please refer to table 2.2 below for standard paths. Attribute is case sensitive, observe the case of path when specifying.
Baudrate	300...115200bps	UART baudrate, currently supported values 300; 600; 1200; 2400; 4800; 9600; 19200; 38400; 57600 and 115200 bits per second (default 115200bps)
DataBits	7 or 8	UART data bit count 7 or 8 (default 8 bits) Attribute is optional and doesn't have to be included in configuration, default value will be used is omitted.
Parity	N; E or O	UART parity, currently supported N = None; E = Even; O = Odd (default E = Even)
StopBits	1 or 2	UART stop bit count 1 or 2 (default 1 bit) Attribute is optional and doesn't have to be included in configuration, default value will be used is omitted.
Timeout	0.01...42949	Timeout value in seconds. New outgoing message will be sent, if there was no reply from outstation within a configured number of seconds.
TxDelay	0.00001...42949	Transmit delay in seconds. Outgoing message will be delayed for a configured number of seconds before being sent after previously received message. Attribute is optional and doesn't have to be included in configuration, default value will be calculated based on configured baudrate.

Continued on next page

Table 2.1 – continued from previous page

Attribute	Values or range	Description
CtrlRdTimer	0 or 0.00001...42949	UART control line (e.g. DSR, RI pin) reading interval in seconds. UART control lines must remain in the same state for least 8 times configured interval before state change will be reported. Default value 0 disables UART control line reading. <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Name	Max 100 chars	Freely configurable name, just for reference. <i>Name attribute is optional and doesn't have to be included in configuration.</i>

* Standard paths of serial ports are summarized in the table [2.2](#) below:

Table 2.2 Standard serial port path

Port Number	LEANDC-2/3 path Devpath attribute	LEANDC-2/5 path Devpath attribute
COM1	/dev/ttyS0	/dev/ttyS0
COM2	/dev/ttyAP0	/dev/ttyS1
COM3	/dev/ttyAP1	/dev/ttyS4
COM4	n/a	/dev/ttyS5
COM5	n/a	/dev/ttyS2

2.2.2 TCPSERVER element node

Settings of the TCP server sockets are configured using [TCPSERVER](#) element node. Please see sample [TCPSERVER](#) element node and the table listing all available attributes below.

```
<TCPSERVER Index="1"
  ServerIPAddr="127.0.0.1"
  Port="2404"
  Timeout="2"
  TxDelay="0.1"
  IdleTimeout="10"
  Name="LAN1"/>
```

Table 2.3 Leandc TCPSERVER node

Attribute	Values or range	Description
Index	1...254	Index is a unique identifier of the hardware node. It is used as a reference to link a communication protocol instance to this node. <i>Indexes don't have to be in a sequential order.</i>
ServerIPAddr	0.0.0.0 ... 255.255.255.254	Server IPv4 address. There must be a local Ethernet interface with this address assigned in order for leandc to open the socket. Remote TCP clients will be available to connect only through Ethernet interface with this local address. Address 0.0.0.0 can be used to allow TCP clients to connect through any running Ethernet interface. (default address 0.0.0.0 (only for testing purposes))
Port	1...65534	TCP port number. This local port will accept unlimited incoming TCP connections as long as there is a communication protocol or supervision instance available to handle the new connection. (default port for IEC 60870-5-104 is 2404)
Timeout	0.01...42949	Timeout value in seconds, only used if serial protocol is linked to this TCPSERVER node. New outgoing message will be sent, if there was no reply from outstation within a configured number of seconds. (default 2 seconds) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
TxDelay	0.00001...42949	Transmit delay in seconds, only used if serial protocol is linked to this TCPSERVER node. Outgoing message will be delayed for a configured number of seconds before being sent after previously received message. (default 0.1 seconds) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
IdleTimeout	5...2 ³² - 1	Receive idle timeout, only used if serial protocol or supervision instance is linked to this TCPSERVER node. TCP socket will be closed if no data is received from peer within this timeout. (default 120 seconds) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Name	Max 100 chars	Freely configurable name, just for reference. <i>Name attribute is optional and doesn't have to be included in configuration.</i>

2.2.3 TCPCLIENT element node

Settings of the TCP client sockets are configured using [TCPCLIENT](#) element node. Please see sample [TCPCLIENT](#) element node and the table listing all available attributes below.

```
<TCPCLIENT Index="1"
  ServerIPAddr="127.0.0.1"
  Port="2404"
  ConnectTimeout="5"
  Timeout="2"
  TxDelay="0.1"
  IdleTimeout="10"
  Name="LAN1" />
```

Table 2.4 Leandc TCPCLIENT node

Attribute	Values or range	Description
Index	1...254	Index is a unique identifier of the hardware node. It is used as a reference to link a communication protocol instance to this node. <i>Indexes don't have to be in a sequential order.</i>
ServerIPAddr	0.0.0.0 ... 255.255.255.254	Server IPv4 address. TCP connection will established to this remote address. (default localhost address 127.0.0.1 (only for testing purposes))
Port	1...65534	TCP port number. TCP connection will be established to the remote port. (default port for IEC 60870-5-104 is 2404)
ConnectTimeout	$1 \dots 2^{32} - 1$	TCP socket reconnection timeout in seconds. Connection request (SYN) message will be sent after this timeout if existing (or new) socket connection fails. (default 5 seconds) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Timeout	0.01...42949	Timeout value in seconds, only used if serial protocol is linked to this TCPCLIENT node. New outgoing message will be sent, if there was no reply from outstation within a configured number of seconds. (default 2 seconds) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
TxDelay	0.00001...42949	Transmit delay in seconds, only used if serial protocol is linked to this TCPSERVER node. Outgoing message will be delayed for a configured number of seconds before being sent after previously received message. (default 0.1 seconds) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
IdleTimeout	$5 \dots 2^{32} - 1$	Receive idle timeout, only used if serial protocol or supervision instance is linked to this TCPCLIENT node. TCP socket will be closed if no data is received from peer within this timeout. (default 120 seconds) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Name	Max 100 chars	Freely configurable name, just for reference. <i>Name attribute is optional and doesn't have to be included in configuration.</i>

2.2.4 UDP element node

Settings of the UDP sockets are configured using [UDP](#) element node. Please see sample [UDP](#) element node and the table listing all available attributes below.

```
<UDP      Index="1"
      RemoteIPAddr="127.0.0.1"
      RemotePort="64950"
      LocalIPAddr="0.0.0.0"
      LocalPort="64950"
      ConnectTimeout="5"
      Timeout="2"
      TxDelay="0.1"
      IdleTimeout="10"
      Name="LAN1" />
```

Table 2.5 Leandc UDP node

Attribute	Values or range	Description
Index	1...254	Index is a unique identifier of the hardware node. It is used as a reference to link a communication protocol instance to this node. <i>Indexes don't have to be in a sequential order.</i>
RemoteIPAddr	0.0.0.0 ... 255.255.255.254	Remote IPv4 address. UDP socket will send messages to this remote address. (default localhost address 127.0.0.1 (only for testing purposes))
RemotePort	1...65534	Remote UDP port number. UDP socket will send messages to this remote port. (default port for supervision instances is 64950)
LocalIPAddr	0.0.0.0 ... 255.255.255.254	Local IPv4 address. There must be a local Ethernet interface with this address assigned in order for leandc to open the socket. UDP messages will be received if remote peer sends them to Ethernet interface with this local address. Address 0.0.0.0 can be used to receive UDP messages through any running Ethernet interface. (default address 0.0.0.0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
LocalPort	1...65534	Local UDP port number. This local port will accept UDP messages. (default port number is equal to the RemotePort) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
ConnectTimeout	$1 \dots 2^{32} - 1$	Socket reconnection timeout in seconds. Communication will be suspended for a configured number of seconds if last UDP message sent was rejected (default 5 seconds) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Timeout	0.01...42949	Timeout value in seconds, only used if serial protocol is linked to this UDP node. New outgoing message will be sent, if there was no reply from outstation within a configured number of seconds. (default 2 seconds) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>

Continued on next page

Table 2.5 – continued from previous page

Attribute	Values or range	Description
TxDelay	0.00001...42949	Transmit delay in seconds, only used if serial protocol is linked to this UDP node. Outgoing message will be delayed for a configured number of seconds before being sent after previously received message. (default 0.1 seconds) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
IdleTimeout	$5 \dots 2^{32} - 1$	Receive idle timeout, only used if OVERRIDE supervision instance is linked to this UDP node. TCP socket used for service commands will be closed if no data is received from peer within this timeout (default 120 seconds) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Name	Max 100 chars	Freely configurable name, just for reference. <i>Name attribute is optional and doesn't have to be included in configuration.</i>

2.3 CommunicationCfg group node

[CommunicationCfg](#) node is used to initialize communication protocol instances and link to physical hardware interface. Leandc firmware is able to receive data from downstream outstations via various communication protocols, process the received information and report it upstream to SCADA system or any other data acquisition unit. Every logical communication link to outstation or upstream Master station has a definition 'communication protocol instance' within this manual and leandc firmware. It represents communication channel for receiving or sending the data to/from leandc. Communication protocol instances have to be configured under [CommunicationCfg](#) node, please refer to the sample below containing 4 different communication protocols (instances).

```
<CommunicationCfg>
  <IEC101ma Index="10" HWIndex="2" XMLpath="IEC101ma_test.xml" CommsFlags="0x10"/>
  <IEC101sl Index="5" HWIndex="1" XMLpath="IEC101sl_test.xml"/>
  <IEC104sl Index="12" HWIndex="3" XMLpath="IEC104ma_test.xml" FilterID="2"/>
  <IEC104Rsl Index="13" HWIndex="3" RedundantToIndex="12" FilterID="3"/>
</CommunicationCfg>
```

Important:

There must be one and only one [CommunicationCfg](#) group node specified under root object node [MainConfig](#) in configuration file 'leandc.xml'.

Communication protocol instances must be listed under [CommunicationCfg](#) group node in the following order:

[Modbusma](#)
[IEC101ma](#)
[IEC101sl](#)
[IEC103ma](#)
[IEC104ma](#)
[IEC104sl](#)
[IEC104Rsl](#)
[IEC104Cs/](#)

Every communication protocol instance has a unique element node and its configuration is described in the following paragraphs.

2.3.1 Modbusma element node

General settings of the Modbus Master communication protocol instance. Please see sample [Modbusma](#) element node and the table listing all available attributes below.

```
<Modbusma      Index="10"
               HWIndex="2"
               XMLpath="BCDI16_test.xml"
               Address="5"
               CommsFlags="0x80"
               Name="IO device"/>
```

Table 2.6 Leandc Modbusma node

Attribute	Values or range	Description
Index	1...254	Index is a unique identifier of the communication protocol instance. It is used to reference protocol instance from other configuration files e.g. IO object tables (please see DI.Device ; AI.Device ; DO.Device ; AO.Device attributes of the Slave protocol instance) <i>Indexes don't have to be in a sequential order.</i>
HWIndex	1...254	Hardware Index is used to link a communication protocol instance to a hardware node. Use value of the UART.Index ; TCPSERVER.Index ; TCPCLIENT.Index or UDP.Index attribute as a hardware index in order to link the protocol instance. <i>Multiple Modbusma communication protocol instances can share the same hardware node.</i>
XMLpath	Max 100 chars	Communication protocol instance XML configuration file name and path. This file contains IO object table as well as additional settings. File path may be omitted if XML file is stored in the same directory as leandc firmware (/home/leandc/app by default) <i>Attribute is case sensitive, observe the case of path and file name when specifying.</i>
Address	1...254	Device address of the outstation. Connected station must have the same device address. Please note value 255 is Broadcast address and can't be used.
CommsFlags	See table 2.14 for description	Initialization settings of the protocol instance. <i>Attribute is optional and doesn't have to be included in configuration, default system settings will be used if omitted.</i>
Name	Max 100 chars	Freely configurable name, just for reference. <i>Name attribute is optional and doesn't have to be included in configuration.</i>

2.3.2 IEC101ma element node

General settings of the IEC60870-5-101 controlling station (Master) communication protocol instance. Please see sample [IEC101ma](#) element node and the table listing all available attributes below.

```
<IEC101ma      Index="10"
               HWIndex="2"
               XMLpath="IEC101ma_test.xml"
               LinkAddr="5"
               ASDUAddr="5"
               CommsFlags="0x80"
               Name="Radio Comms" />
```

Table 2.7 Leandc IEC101ma node

Attribute	Values or range	Description
Index	1...254	Index is a unique identifier of the communication protocol instance. It is used to reference protocol instance from other configuration files e.g. IO object tables (please see DI.Device ; AI.Device ; DO.Device ; AO.Device attributes of the Slave protocol instance) Indexes don't have to be in a sequential order.
HWIndex	1...254	Hardware Index is used to link the communication protocol instance to a hardware node. Use value of the UART.Index ; TCPSEVER.Index ; TCPCLIENT.Index or UDP.Index attribute as a hardware index in order to link the protocol instance. Multiple IEC101ma communication protocol instances can be linked to the same hardware node.
XMLpath	Max 100 chars	Communication protocol instance XML configuration file name and path. This file contains IO object table as well as additional settings. File path may be omitted if XML file is stored in the same directory as leandc firmware (/home/leandc/app by default) Attribute is case sensitive, observe the case of path and file name when specifying.
LinkAddr	1...254 or 1...65534	Link layer address of the communication protocol instance. Addresses must be equal for the 'Master' and 'Slave' station communicating to each other. Size of the link layer address may be 1 or 2 bytes and it is configured using the LinkSettings.LinkAddrSize attribute. Please note values 255 (if link layer address size is 1 byte) and 65535 (if link layer address size is 2 bytes) are Global addresses and can't be used.
ASDUAddr	1...254 or 1...65534	Common address of ASDU (CAA). Size of the common ASDU address may be 1 or 2 bytes and it is configured using the ASDUSettings.CAASize attribute. Please note values 255 (if ASDU address size is 1 byte) and 65535 (if ASDU address size is 2 bytes) are Broadcast addresses and can't be used. ASDUAddr attribute is optional and doesn't have to be included in configuration, value of the LinkAddr will be used if omitted.
CommsFlags	See table 2.14 for description	Initialization settings of the protocol instance. Attribute is optional and doesn't have to be included in configuration, default system settings will be used if omitted.

Continued on next page

Table 2.7 – continued from previous page

Attribute	Values or range	Description
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

2.3.3 IEC101sl element node

General settings of the IEC60870-5-101 controlled station (Slave) communication protocol instance. Please see sample [IEC101sl](#) element node and the table listing all available attributes below.

```
<IEC101sl Index="5"
  HWIndex="1"
  XMLpath="IEC101sl_test.xml"
  LinkAddr="5"
  ASDUAddr="5"
  Source="6"
  CommsFlags="0x80"
  Name="Serial SCADA"/>
```

Table 2.8 Leandc IEC101sl node

Attribute	Values or range	Description
Index	1...254	Index is a unique identifier of the communication protocol instance. It is used to reference protocol instance from other configuration files e.g. logfile configuration XML file. Indexes don't have to be in a sequential order.
HWIndex	1...254	Hardware Index is used to link the communication protocol instance to a hardware node. Use value of the UART.Index ; TCPSEVER.Index ; TCPCLIENT.Index or UDP.Index attribute as a hardware index in order to link the protocol instance. Multiple IEC101sl communication protocol instances can be linked to the same hardware node.
XMLpath	Max 100 chars	Communication protocol instance XML configuration file name and path. This file contains IO object table as well as additional settings. File path may be omitted if XML file is stored in the same directory as leandc firmware (/home/leandc/app by default) Attribute is case sensitive, observe the case of path and file name when specifying.
LinkAddr	1...254 or 1...65534	Link layer address of the communication protocol instance. Addresses must be equal for the 'Master' and 'Slave' station communicating to each other. Size of the link layer address may be 1 or 2 bytes and it is configured using the LinkSettings.LinkAddrSize attribute. Please note values 255 (if link layer address size is 1 byte) and 65535 (if link layer address size is 2 bytes) are Global addresses and can't be used.
ASDUAddr	1...254 or 1...65534	Common address of ASDU (CAA). Size of the common ASDU address may be 1 or 2 bytes and it is configured using the ASDUSettings.CAASize attribute. Please note values 255 (if ASDU address size is 1 byte) and 65535 (if ASDU address size is 2 bytes) are Broadcast addresses and can't be used. ASDUAddr attribute is optional and doesn't have to be included in configuration, value of the LinkAddr will be used if omitted.
Source	1...254	Source communication protocol instance index. IO objects without individual DI.Device ; AI.Device ; DO.Device ; AO.Device attributes specified will be linked to this protocol instance. Attribute is optional and doesn't have to be included in configuration, IO object :xmlref:'Device' attributes will be used if omitted.'

Continued on next page

Table 2.8 – continued from previous page

Attribute	Values or range	Description
CommsFlags	See table 2.14 for description	Initialization settings of the protocol instance. <i>Attribute is optional and doesn't have to be included in configuration, default system settings will be used if omitted.</i>
Name	Max 100 chars	Freely configurable name, just for reference. <i>Name attribute is optional and doesn't have to be included in configuration.</i>

2.3.4 IEC103ma element node

General settings of the IEC60870-5-103 controlling station (Master) communication protocol instance. Please see sample [IEC103ma](#) element node and the table listing all available attributes below.

```
<IEC103ma      Index="20"
              HWIndex="3"
              XMLpath="Feeder_F1.xml"
              LinkAddr="5"
              ASDUAddr="5"
              CommsFlags="0x80"
              Name="Feeder_IED1" />
```

Table 2.9 Leandc IEC103ma node

Attribute	Values or range	Description
Index	1...254	Index is a unique identifier of the communication protocol instance. It is used to reference protocol instance from other configuration files e.g. IO object tables (please see DI.Device ; AI.Device ; DO.Device ; AO.Device attributes of the Slave protocol instance) Indexes don't have to be in a sequential order.
HWIndex	1...254	Hardware Index is used to link the communication protocol instance to a hardware node. Use value of the UART.Index ; TCPSERVER.Index ; TCPCLIENT.Index or UDP.Index attribute as a hardware index in order to link the protocol instance. Multiple IEC103ma communication protocol instances can be linked to the same hardware node.
XMLpath	Max 100 chars	Communication protocol instance XML configuration file name and path. This file contains IO object table as well as additional settings. File path may be omitted if XML file is stored in the same directory as leandc firmware (/home/leandc/app by default) Attribute is case sensitive, observe the case of path and file name when specifying.
LinkAddr	1...254	Link layer address of the communication protocol instance. Addresses must be equal for the 'Master' and 'Slave' station communicating to each other. Size of the link layer address may be 1 or 2 bytes and it is configured using the LinkSettings.LinkAddrSize attribute. Please note values 255 is Global addresses and can't be used.
ASDUAddr	1...254	Common address of ASDU (CAA). There is only one ASDU available in IEC 60870-5-103 Master station and addresses must be equal for the 'Master' and 'Slave' station communicating to each other. Please note value 255 is Broadcast address and can't be used. ASDUAddr attribute is optional and doesn't have to be included in configuration, LinkAddr value will be used if omitted.
CommsFlags	See table 2.14 for description	Initialization settings of the protocol instance. Attribute is optional and doesn't have to be included in configuration, default system settings will be used if omitted.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

2.3.5 IEC104ma element node

General settings of the IEC60870-5-104 controlling station (Master) communication protocol instance. Please see sample [IEC104ma](#) element node and the table listing all available attributes below.

```
<IEC104ma      Index="20"
               HWIndex="2"
               XMLpath="IEC104ma_test.xml"
               ASDUAddr="5"
               StationID="2"
               CommsFlags="0x10"
               Name="RTU" />
```

Table 2.10 Leandc IEC104ma node

Attribute	Values or range	Description
Index	1...254	Index is a unique identifier of the communication protocol instance. It is used to reference protocol instance from other configuration files e.g. IO object tables (please see DI.Device ; AI.Device ; DO.Device ; AO.Device attributes of the Slave protocol instance) <i>Indexes don't have to be in a sequential order.</i>
HWIndex	1...254	Hardware Index is used to link the communication protocol instance to a hardware node. Use value of the TCPCLIENT.Index attribute as a hardware index in order to link the protocol instance. <i>Multiple IEC104ma communication protocol instances can be linked to the same hardware node.</i>
XMLpath	Max 100 chars	Communication protocol instance XML configuration file name and path. This file contains IO object table as well as additional settings. File path may be omitted if XML file is stored in the same directory as leandc firmware (/home/leandc/app by default) <i>Attribute is case sensitive, observe the case of path and file name when specifying.</i>
ASDUAddr	1...65534	Common address of ASDU (CAA). Please note value 65535 is Broadcast address and can't be used.
StationID	1...254	Station identifier. Multiple ASDUs (communication protocol instances) can share a common transport interface referred as 'station'. Station identifier is unique per hardware node so it is possible to have multiple stations with the same identifier providing these are linked to separate hardware nodes. <i>Attribute is optional and doesn't have to be included in configuration, each protocol instance will create its own transport interface (unique 'station') if attribute omitted.</i>
CommsFlags	See table 2.14 for description	Initialization settings of the protocol instance. <i>Attribute is optional and doesn't have to be included in configuration, default system settings will be used if omitted.</i>
Name	Max 100 chars	Freely configurable name, just for reference. <i>Name attribute is optional and doesn't have to be included in configuration.</i>

2.3.6 IEC104sl element node

General settings of the IEC60870-5-104 controlled station (Slave) communication protocol instance. Please see sample [IEC104sl](#) element node and the table listing all available attributes below.

```
<IEC104sl    Index="12"
            HWIndex="4"
            XMLpath="IEC104sl_test.xml"
            ASDUAddr="5"
            StationID="2"
            FilterID="0"
            Source="6"
            CommsFlags="0x80"
            Name="SCADA"/>
```

Table 2.11 Leandc IEC104sl node

Attribute	Values or range	Description
Index	1...254	Index is a unique identifier of the communication protocol instance. It is used to reference protocol instance from other configuration files e.g. logfile configuration XML file. Indexes don't have to be in a sequential order.
HWIndex	1...254	Hardware Index is used to link the communication protocol instance to a hardware node. Use value of the TCPSEVER.Index attribute as a hardware index in order to link the protocol instance. Multiple IEC104sl communication protocol instances can be linked to the same hardware node.
XMLpath	Max 100 chars	Communication protocol instance XML configuration file name and path. This file contains IO object table as well as additional settings. File path may be omitted if XML file is stored in the same directory as leandc firmware (/home/leandc/app by default) Attribute is case sensitive, observe the case of path and file name when specifying.
ASDUAddr	1...65534	Common address of ASDU (CAA). Please note value 65535 is Broadcast address and can't be used.
StationID	1...254	Station identifier. Multiple ASDUs (communication protocol instances) can share a common transport interface referred as 'station'. Station identifier is unique per hardware node so it is possible to have multiple stations with the same identifier providing these are linked to separate hardware nodes. Attribute is optional and doesn't have to be included in configuration, each protocol instance will create its own transport interface (unique 'station') if attribute omitted.
FilterID	1...255	Identifier of a predefined filter to restrict the range of TCP client IP addresses allowed to establish connection to the protocol instance. Please refer to the table 2.17 for filter settings. FilterID attribute is optional and doesn't have to be included in configuration.
Source	1...254	Source communication protocol instance index. IO objects without individual DI.Device ; AI.Device ; DO.Device ; AO.Device attributes specified will be linked to this protocol instance. Attribute is optional and doesn't have to be included in configuration, IO object :xmlref:'Device' attributes will be used if omitted.'

Continued on next page

Table 2.11 – continued from previous page

Attribute	Values or range	Description
CommsFlags	See table 2.14 for description	Initialization settings of the protocol instance. <i>Attribute is optional and doesn't have to be included in configuration, default system settings will be used if omitted.</i>
Name	Max 100 chars	Freely configurable name, just for reference. <i>Name attribute is optional and doesn't have to be included in configuration.</i>

2.3.7 IEC104Rsl element node

There is an option to use multiple redundant connections for communication between leandc and controlling (Master) stations ensuring a failure of a single communication channel will not disrupt the exchange of data. This option is currently available for leandc IEC60870-5-104 controlled station (Slave) mode and can be enabled by creating a redundancy group. Redundancy group is a number of leandc communication protocol instances which are working together allowing several controlling stations (Masters) to receive the same data over single/multiple communication channels. Only one controlling station (Master) within a redundancy group is in a 'Started state' which means it is exchanging the application data with leandc. Other controlling stations (Masters) are in a 'Stopped state', they only monitor availability of the communication channel and do not exchange the application data.

In order to explain how to configure a redundancy group in leandc there are two terms 'Main' ([IEC104sl](#) node) and 'Redundant' ([IEC104Rsl](#) node) communication protocol instance used throughout this manual. There is no functional difference between 'Main' and 'Redundant' communication protocol instance as far as communication standard is concerned, these are only used to reference different types of nodes in leandc configuration.

IEC60870-5-104 controlled station (Slave) redundancy group in leandc is enabled as follows: any [IEC104sl](#) node can be chosen as 'Main' communication protocol instance and redundancy is automatically enabled if one or more [IEC104Rsl](#) nodes are linked to the 'Main' communication protocol instance. It is possible to link up to 15 'Redundant' communication protocol instances to the same 'Main' communication protocol instance, thus creating a redundancy group of 16. This allows for up to 16 controlling (Master) stations to connect to leandc.

No IO object XML configuration is required for 'Redundant' communication protocol instance, because it is always linked to 'Main' communication protocol instance, which has an IO object table and the application data will be shared by all instances within a redundancy group. Please see sample [IEC104Rsl](#) element node and the table listing all available attributes below.

```
<IEC104Rsl    Index="13"
              HWIndex="3"
              RedundantToIndex="12"
              FilterID="0"
              CommsFlags="0x80"
              Name="SCADA" />
```

Table 2.12 Leandc IEC104Rsl node

Attribute	Values or range	Description
Index	1...254	Index is a unique identifier of the communication protocol instance. It is used to reference protocol instance from other configuration files e.g. logfile configuration XML file. <i>Indexes don't have to be in a sequential order.</i>
HWIndex	1...254	Hardware Index is used to link the communication protocol instance to a hardware node. Use value of the TCPSEVER.Index attribute as a hardware index in order to link the protocol instance. <i>Multiple IEC104Rsl communication protocol instances can be linked to the same hardware node.</i>
RedundantToIndex	1...254	Link current 'Redundant' communication protocol instance to 'Main' communication protocol instance. Use value of the IEC104sl.Index attribute.
FilterID	1...255	Identifier of a predefined filter to restrict the range of TCP client IP addresses allowed to connect to the protocol instance. Please refer to the table 2.17 for filter settings. <i>Attribute is optional and doesn't have to be included in configuration.</i>
Continued on next page		

Table 2.12 – continued from previous page

Attribute	Values or range	Description
CommsFlags	See table 2.14 for description	Initialization settings of the protocol instance. Attribute is optional and doesn't have to be included in configuration, default system settings will be used if omitted.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

Example configuration below, redundancy group of 4 instances is created allowing up to 4 controlling (Master) stations to connect to leandc.

```
<CommunicationCfg>
  <IEC104s1 Index="12" HWIndex="3" XMLpath="IEC104ma_test.xml" Name="SCADA1"/>
  <IEC104Rs1 Index="13" HWIndex="3" RedundantToIndex="12" Name="SCADA2"/>
  <IEC104Rs1 Index="14" HWIndex="3" RedundantToIndex="12" Name="SCADA3"/>
  <IEC104Rs1 Index="15" HWIndex="3" RedundantToIndex="12" Name="SCADA4"/>
</CommunicationCfg>
```

2.3.8 IEC104Csl element node

There is an option to clone communication protocol instances which share a common transport interface (same [StationID](#) attribute) to create identical communication protocol instances linked to identical transport interface. This option might be useful in a situation where number of communication protocol instances (ASDUs) are linked to the same transport interface (station) and there is a need to create identical copy of such configuration e.g. to be linked to different hardware node. It can be easily achieved using [IEC104Csl](#) element node.

Please see sample [IEC104Csl](#) element node and the table listing all available attributes below.

```
<IEC104Csl    Index="13"
              HWIndex="3"
              CloneFromIndex="12"
              StationID="5"
              FilterID="0"
              CommsFlags="0x80"
              Name="SCADA"/>
```

Table 2.13 Leandc IEC104Csl node

Attribute	Values or range	Description
Index	1...254	Base index of the first cloned communication protocol instance. If there are more protocol instances linked to the same transport interface as the instance which is being cloned, all of those will be cloned and their indexes will be initialized sequentially. <i>Indexes don't have to be in a sequential order.</i>
HWIndex	1...254	Hardware Index is used to link cloned communication protocol instance(s) to a hardware node. Use value of the TCPSEVER.Index attribute as a hardware index in order to link the cloned protocol instance(s). <i>Multiple IEC104Csl communication protocol instances can be linked to the same hardware node.</i>
CloneFromIndex	1...254	Source communication protocol instance to be cloned. All protocol instances linked to the same transport interface (station) will be cloned. Use value of the IEC104sl.Index attribute.
StationID	1...254	Station identifier. Multiple ASDUs (communication protocol instances) can share a common transport interface referred as 'station'. Station identifier is unique per hardware node so it is possible to have multiple stations with the same identifier providing these are linked to separate hardware nodes. <i>Attribute is optional and doesn't have to be included in configuration, cloned protocol instance will create its own transport interface (unique 'station') if attribute omitted.</i>
FilterID	1...255	Identifier of a predefined filter to restrict the range of TCP client IP addresses allowed to establish connection to the protocol instance(s). Please refer to the table 2.17 for filter settings. <i>Attribute is optional and doesn't have to be included in configuration.</i>
CommsFlags	See table 2.14 for description	Initialization settings of the protocol instance(s). <i>Attribute is optional and doesn't have to be included in configuration, default system settings will be used if omitted.</i>
Name	Max 100 chars	Freely configurable name, just for reference. <i>Name attribute is optional and doesn't have to be included in configuration.</i>

2.3.9 CommsFlags attribute

Communication flags are used to configure initialization settings of some communication protocol instances. For example, outstation polling can be disabled on leandc startup and enabled by user later on issuing a service command.

Table 2.14 CommsFlags attribute

Bits	Values	Description
CommsFlags [xxxx.xxxx]	0...0xFF	CommsFlags is 8 bit encoded variable.
Bit 3	xxxx.0xxx	Reject new incoming connection to TCP server if protocol instance is already connected (default value)
	xxxx.1xxx	Always accept new incoming connection to TCP server and terminate previous connection if protocol instance is already connected
Bit 4	xxx0.xxxx	IEC 60870-5-104 controlling station (Master) communication protocol instance sends [STARTDT_act] to outstation upon leandc startup (default value)
	xxx1.xxxx	IEC 60870-5-104 controlling station (Master) communication protocol instance doesn't send [STARTDT_act] to outstation upon leandc startup
Bit 7	0xxx.xxxx	Protocol instance communication to peer station is enabled upon leandc startup (default value)
	1xxx.xxxx	Protocol instance communication to peer station is disabled upon leandc startup
Bits 0...2;5;6	Any	Bits reserved for future use

2.4 TraceCfg group and SYSLOGFILE node

Group object node [TraceCfg](#) and its child element node [SYSLOGFILE](#) is used to configure system logfile where generic diagnostic and error messages will be recorded. Only one [SYSLOGFILE](#) element node can be defined under [TraceCfg](#). Please see sample [TraceCfg](#) and [SYSLOGFILE](#) nodes and the table listing all available attributes below.

```
<TraceCfg>
  <SYSLOGFILE LogFlags="0" Mode="0" HourLimit="4" Logfile="Syslog/syslog"/>
</TraceCfg>
```

Table 2.15 Leandc SYSLOGFILE attributes

Attribute	Values or range	Description
LogFlags	See table 2.16 for description	LogFlags specify the type of system information to be recorded to a logfile.
Logfile	Max 200 chars	System logfile name without an extension, but including absolute or relative path. Logfile will be created in the same folder as leandc firmware if path is not specified. The date and extension 'log' will be added to the file name automatically. Logfile will not be created if attribute is left blank. (default entry 'Syslog/aaa', where 'aaa' is name of the file) Attribute is case sensitive, observe the case of path and file name when specifying.
Mode*	See table 11.5 for description	New logfile initialization settings. (default value 0) Attribute is optional and doesn't have to be included in configuration, default settings will be used if omitted.
HourLimit*	0...12	New file will created after selected number of hours in order to limit the size. (default 0 hours – only one logfile per day will be created) Attribute is optional and doesn't have to be included in configuration, default settings will be used if omitted.

Tip:

* Please refer to the ([ref](#)) for a sample list of files created based on settings in [SYSLOGFILE.HourLimit](#) and [SYSLOGFILE.Mode](#) attributes.

Table 2.16 LogFlags attribute

Bits	Values	Description
LogFlags [xxxx.xxxx]	0...0xFF	LogFlags is 8 bit encoded variable. Logfile will not be created, if value is 0
Bit 0	xxxx.xxx0	System information recording to logfile disabled
	xxxx.xxx1	System information recording to logfile enabled
Bits 2...7	Any	Bits reserved for future use

2.5 ClientFilterCfg group and IPv4 node

Group object node [ClientFilterCfg](#) and its child element nodes [IPv4](#) are used to create filters to allow only specific remote 'Client' IP address connection to leandc 'Server' socket. Please see sample [ClientFilterCfg](#) and [IPv4](#) nodes and the table listing all available attributes below.

```
<ClientFilterCfg>
  <IPv4 FilterID="1" ClientIPAddr="192.168.2.14" Mask="32"/>
  <IPv4 FilterID="1" ClientIPAddr="192.168.2.55" Mask="32"/>
  <IPv4 FilterID="2" ClientIPAddr="192.168.5.0" Mask="24"/>
</ClientFilterCfg>
```

There are three [IPv4](#) filter nodes configured in the above example. Please note there are two [IPv4](#) nodes with the same filter identifier number '1'. This will create a filter which allow both IP address 192.168.2.14 and 192.168.2.55 connection to leandc.

Table 2.17 Leandc ClientFilterCfg group node IPv4 attributes

Attribute	Values or range	Description
FilterID	1...255	Filter identifier number. More than one filter may have the same identifier number which increases the flexibility of defining multiple allowed addresses or address ranges. In order to apply filter, use this identifier number in communication protocol instance attributes IEC104sl.FilterID ; IEC104Rsl.FilterID or IEC104Csl.FilterID .
ClientIPAddr	0.0.0.0 ... 255.255.255.255	IPv4 TCP client IP address allowed to connect to leandc 'Server' socket. It is also possible to define a network subnet and all IP addresses of the subnet will be able to connect to leandc. Please refer to IPv4.Mask attribute for network subnet configuration. (address 0.0.0.0 can be used to allow connection from any IP address)
Mask	0...32	Network mask is used in conjunction with IPv4.ClientIPAddr attribute in order to create a network subnet. All IP addresses of the subnet will be able to connect to leandc 'Server' socket. Network mask attribute is a decimal representation of the subnet mask, sometimes called network prefix, refer to table 18 for more information. (Mask 0 will allow connection from any IP address; mask 32 will allow connection only from one IP address specified in IPv4.ClientIPAddr attribute)
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

Table below is used to show network subnets created by different [IPv4.Mask](#) attribute values and its layout is based on assumption user has a good understanding of network addressing fundamentals. Please refer to external sources (e.g. <http://www.subnet-calculator.com>) for additional information on network addressing and subnet definition.

Table column 1 contains [IPv4.Mask](#) attribute values, column 2 contains subnet mask represented in dotted decimal notation, following columns show network mask in binary format (just for reference) and the last column contains range of IP address allowed to connect to leandc. Table can be used as a guidance of how network subnets are created based on sample IP address 192.168.1.1 specified in [IPv4.ClientIPAddr](#) attribute.

Table 2.18 Network Mask sample values

Mask	Subnet mask	Subnet mask binary value				IP range allowed to connect
0	0.0.0.0	0000 0000	0000 0000	0000 0000	0000 0000	Mask off – any client IPv4 address allowed
1	128.0.0.0	1000 0000	0000 0000	0000 0000	0000 0000	128.0.0.0 to 255.255.255.255
2	192.0.0.0	1100 0000	0000 0000	0000 0000	0000 0000	192.0.0.0 to 255.255.255.255
3	224.0.0.0	1110 0000	0000 0000	0000 0000	0000 0000	192.0.0.0 to 223.255.255.255
...						
24	255.255.255.0	1111 1111	1111 1111	1111 1111	0000 0000	192.168.1.0 to 192.168.1.255
25	255.255.255.128	1111 1111	1111 1111	1111 1111	1000 0000	192.168.1.0 to 192.168.1.127
26	255.255.255.192	1111 1111	1111 1111	1111 1111	1100 0000	192.168.1.0 to 192.168.1.63
27	255.255.255.224	1111 1111	1111 1111	1111 1111	1110 0000	192.168.1.0 to 192.168.1.31
28	255.255.255.240	1111 1111	1111 1111	1111 1111	1111 0000	192.168.1.0 to 192.168.1.15
29	255.255.255.248	1111 1111	1111 1111	1111 1111	1111 1000	192.168.1.0 to 192.168.1.7
30	255.255.255.252	1111 1111	1111 1111	1111 1111	1111 1100	192.168.1.0 to 192.168.1.3
31	255.255.255.254	1111 1111	1111 1111	1111 1111	1111 1110	192.168.1.0 to 192.168.1.1
32	255.255.255.255	1111 1111	1111 1111	1111 1111	1111 1111	Only 192.168.1.1 allowed to connect

2.6 SupervisionCfg group node

Group object node [SupervisionCfg](#) is used to configure leandc serial port or socket real-time traffic monitoring and also enables serial server functionality. Real-time traffic monitoring and serial server functionality has designated supervision instances which are configured under [SupervisionCfg](#) group node, please refer to the sample below containing 4 different supervision instances.

```
<SupervisionCfg>
  <MONRAW SrcHWIndex="1" DstHWIndex="51" Name="Raw monitoring instance"/>
  <MONCOMP SrcHWIndex="2" DstHWIndex="52" SrvHWIndex="53" Name="Compatible mon instance"/>
  <REDIRECT SrcHWIndex="4" DstHWIndex="61" Name="UART redirect instance"/>
  <OVERRIDE SrcHWIndex="3" DstHWIndex="62" SrvHWIndex="63" Name="UART override instance"/>
</SupervisionCfg>
```

Every supervision instance has a unique element node and its configuration is described in the following paragraphs.

Important:

Supervision instances must be listed under [SupervisionCfg](#) group node in the following order:

[MONRAW](#)
[MONCOMP](#)
[REDIRECT](#)
[OVERRIDE](#)

2.6.1 MONRAW element node

Traffic through any leandc serial port or socket can be captured and sent to a remote destination for a real time monitoring. Remote traffic monitoring can be enabled using so called raw monitoring supervision instance which requires only 1 destination socket to send the captured data. Raw monitoring mode will be active as long as there is a traffic through the monitored port and remote destination is reachable. Please see sample [MONRAW](#) element node used to configure raw monitoring and the table listing all available attributes below.

```
<MONRAW SrcHWIndex="1"
        DstHWIndex="51"
        Name="Raw monitoring instance"/>
```

Table 2.19 Leandc MONRAW node

Attribute	Values or range	Description
SrcHWIndex	1...254	Source index of the hardware node to be monitored. Any of UART ; TCPSERVER ; TCPCLIENT or UDP nodes can be used as a source for traffic monitoring.
DstHWIndex	1...254	Destination index of the hardware node to send captured traffic. Any of TCPSERVER or UDP nodes can be used to send captured traffic providing they aren't linked to a communication protocol instance.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

Tip:
[UDP](#) socket is recommended to be used as a destination to send the captured traffic.
Default port for destination node (linked with [DstHWIndex](#)) is 64950.

2.6.2 MONCOMP element node

Traffic through any leandc serial port or socket can be captured and sent to a remote destination for a real time monitoring. Remote traffic monitoring can be enabled using so called compatible monitoring supervision instance which requires 2 sockets for its operation. 1st socket will be the destination to send captured data and the 2nd socket will be used for service commands. Captured data will be send only if both remote destination and socket for service commands are active/reachable. Please see sample [MONCOMP](#) element node used to configure compatible monitoring and the table listing all available attributes below.

```
<MONCOMP SrcHWIndex="2" DstHWIndex="52" SrvHWIndex="53" Name="Compatible monitoring instance"/>
```

Table 2.20 Leandc MONCOMP node

Attribute	Values or range	Description
SrcHWIndex	1...254	Source index of the hardware node to be monitored. Any of UART ; TCPSEVER ; TCPCLIENT or UDP nodes can be used as a source for traffic monitoring.
DstHWIndex	1...254	Destination index of the hardware node to send captured traffic. Any of TCPSEVER or UDP nodes can be used to send captured traffic providing they aren't linked to a communication protocol instance.
SrvHWIndex	1...254	Index of the hardware node for receiving service commands. Any of TCPCLIENT nodes can be used for service commands providing they aren't linked to a communication protocol instance.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

Please note [TCPSEVER.IdleTimeout](#) attribute will be used to check activity of the service socket. The service [TCPSEVER](#) socket will be disconnected if no data is received within a configured number of seconds and also the destination socket is disconnected/unreachable.

Tip:

Default port for destination node (linked with [DstHWIndex](#)) is 64950 and service node (linked with [SrcHWIndex](#)) is 64966.

2.6.3 REDIRECT element node

Serial server functionality in leandc enables to send data from one serial port to another over the network in a transparent mode as if these serial ports were connected together with a direct cable. In order to permanently enable serial server functionality in leandc so called redirect supervision instance can be used. It requires only 1 destination socket to send the redirected data. Serial data will be redirected as long as remote destination is reachable. Please see sample [REDIRECT](#) element node used to configure serial server and the table listing all available attributes below.

```
<REDIRECT SrcHWIndex="4" DstHWIndex="61" Name="UART redirect instance"/>
```

Table 2.21 Leandc REDIRECT node

Attribute	Values or range	Description
SrcHWIndex	1...254	Index of the UART node to be redirected. Data received through this UART will be redirected to a destination hardware node and data received from a destination hardware node will be redirected to this UART. No communication protocol instances must be linked to UART node in order to use for redirection.
DstHWIndex	1...254	Destination index of the hardware node to redirect the UART data. Any of TCPSEVER ; TCPCLIENT or UDP nodes can be used as destination where data received through source UART will be sent. Data received from a destination hardware node will be redirected to source UART.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

Please note [TCPSEVER.IdleTimeout](#) and [TCPCLIENT.IdleTimeout](#) attributes will be used to check activity of the destination socket. The destination [TCPSEVER](#) or [TCPCLIENT](#) sockets will be disconnected if no data is received within a configured number of seconds. This means there has to be an ongoing communication to prevent TCP sockets from being automatically disconnected. This doesn't apply to UDP socket.

Tip:

Default port for destination node (linked with DstHWIndex) is 64950.

2.6.4 OVERRIDE element node

Serial server functionality in leandc enables to send data from one serial port to another over the network in a transparent mode as if these serial ports were connected together with a direct cable. However sometimes it is useful to enable serial server functionality only temporarily and return the port to a normal operation when it is no longer required. It can be used to e.g. temporarily poll or configure a serial device connected to leandc and return to normal operation mode after configuration is complete. Temporary serial server functionality can be enabled using so called override supervision instance which requires 2 sockets for its operation. 1st socket will be the destination to redirect serial data and the 2nd socket will be used for service commands. Serial server functionality will be automatically enabled only if both remote destination and socket for service commands are active/reachable. Please see sample [OVERRIDE](#) element node used to configure temporary serial server and the table listing all available attributes below.

```
<OVERRIDE SrcHWIndex="3" DstHWIndex="62" SrvHWIndex="63" Name="UART override instance"/>
```

Table 2.22 Leandc OVERRIDE node

Attribute	Values or range	Description
SrcHWIndex	1...254	Index of the UART node to be temporarily overridden. Data received through this UART will be temporarily redirected to a destination hardware node and data received from a destination hardware node will be temporarily redirected to this UART.
DstHWIndex	1...254	Destination index of the hardware node to temporarily redirect the UART data. Any of TCPSEVER ; TCPCLIENT or UDP nodes can be used as destination where data received through source UART will be temporarily sent. Data received from a destination hardware node will be temporarily redirected to source UART.
SrvHWIndex	1...254	Index of the hardware node for receiving service commands. Any of TCPSEVER or TCPCLIENT nodes can be used for service commands providing they aren't linked to a communication protocol instance.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

Please note [TCPSEVER.IdleTimeout](#) and [TCPCLIENT.IdleTimeout](#) attributes will be used to check activity of both destination and service sockets. The destination and service [TCPSEVER](#) or [TCPCLIENT](#) sockets will be disconnected if no data is received within a configured number of seconds. Also the service [TCPSEVER](#) or [TCPCLIENT](#) sockets will be disconnected if no data is received within a number of seconds configured in the destination socket [UDP.IdleTimeout](#) attribute. This means there has to be an ongoing communication to prevent TCP sockets from being automatically disconnected.

Tip:

Default port for destination node (linked with [DstHWIndex](#)) is 64950 and service node (linked with [SrcHWIndex](#)) is 64966.

IEC60870-5-101 Slave configuration

This section describes how to configure IEC 60870-5-101 controlled station (Slave) communication protocol instance. Each IEC 60870-5-101 controlled station (Slave) communication protocol instance must have XML configuration file where its IO object table and additional protocol-related settings will be stored. One and the same XML configuration file can be used for multiple IEC 60870-5-101 controlled station (Slave) communication protocol instances, this becomes useful in case if identical IO objects need to be reported to several Master stations.

Name and location path of the XML configuration file are not predefined, they can be chosen freely. File name 'IEC101sl_test.xml' will be used as a sample and location path doesn't need to be specified if XML file is stored in the same directory as leandc firmware. In order to use the XML file for a communication protocol instance, simply enter the name 'IEC101sl_test.xml' in the [IEC101sl.XMLpath](#) attribute.

IEC60870-5-101 Slave configuration file (e.g. 'IEC101sl_test.xml') must have a root object node [IEC101slConfig](#) which has 6 child group object nodes [VersionControl](#); [ProtocolCfg](#); [DITable](#); [AITable](#); [DOTable](#); [AOTable](#) please see the sample below.

```
<IEC101slConfig xmlns="http://www.londelec.com/xmlschemas/leandc/IEC101sl" ... version="1.00">
  <VersionControl conf="4" date="2014-01-18" time="10:08:09"/>
  <ProtocolCfg>
    <XMLSettings IOAOverlap="1" />
    <CommsSettings OfflineDelay="120" />
    ...
  </ProtocolCfg>
  <DITable>
    <DI Device="10" Index="0" InfAddr="1" qualifier="0x10"/>
    ...
  </DITable>
  <AITable>
    <AI Device="10" Index="0" InfAddr="10" qualifier="0x00" Coeff="1.0"/>
    ...
  </AITable>
  <DOTable>
    <DO Device="10" Index="0" InfAddr="1"/>
    ...
  </DOTable>
  <AOTable>
    <AO Device="10" Index="0" InfAddr="1"/>
    ...
  </AOTable>
</IEC101slConfig>
```

[DITable](#); [AITable](#); [DOTable](#); [AOTable](#) group nodes compose an IO object table and they are common for IEC60870-5-101 and IEC60870-5-104 controlled station (Slave) communication protocol instances. Please refer to the tables [5.1](#); [5.5](#); [5.9](#) and [5.13](#) for their attributes.

3.1 ProtocolCfg group node

Protocol settings of the IEC60870-5-101 controlled station (Slave) communication protocol instance are configured using various child element nodes under [ProtocolCfg](#) group node.

Important:

It is essential to keep element nodes in the listed order otherwise it will affect the XML file validation.

Please see sample [ProtocolCfg](#) group node and the table listing all available child element nodes below.

```
<ProtocolCfg>
  <XMLSettings ... />
  <LinkSettings ... />
  <CommsSettings ... />
  <ASDUSettings ... />
  <Timeouts ... />
  <TimeSettings ... />
  <Periodic ... />
  <BufferSizes ... />
</ProtocolCfg>
```

Tip:

All element nodes are optional, default values will be used for attributes of omitted nodes.

Table 3.1 IEC 60807-5-101 Slave ProtocolCfg child element nodes

Attribute	Values or range	Description
XMLSettings	See table 3.2	XML parse setting specification node. Refer to table 3.2 for attribute specification.
LinkSettings	See table 3.3	Communication link layer timeout and control bit configuration node. Refer to table 3.3 for attribute specification.
CommsSettings	See table 3.4	Communication status (e.g. online and offline) change behavior and related delay configuration node. Refer to table 3.4 for attribute specification.
ASDUSettings	See table 3.5	Various application layer settings configuration node. Refer to table 3.5 for attribute specification.
Timeouts	See table 3.6	Control command expiration timeout configuration node. Refer to table 3.6 for attribute specification.
TimeSettings	See table 3.7	Unique time settings (e.g. time zone) of particular protocol instance. Refer to table 3.7 for attribute specification.
Periodic	See table 3.8	Periodically generated message configuration node. Refer to table 3.8 for attribute specification.
BufferSizes	See table 3.9	Various application layer buffer size configuration node. Refer to table 3.9 for attribute specification.

3.1. ProtocolCfg group node

3.1.1 XMLSettings attributes

XML file parse settings such as information object address validation can be specified using attributes of [XMLSettings](#) element node.

Please see sample [XMLSettings](#) node and the table listing all available attributes below.

```
<XMLSettings IOAOverlap="1" />
```

Table 3.2 IEC 60807-5-101 Slave XMLSettings attributes

Attribute	Values or range	Description
IOAOverlap	0	Each information object (DI/AI/DO/AO) specified in an IO table must have unique information object address (IOA). Error message will be generated and IO object table will be purged if address duplication is detected. (default value)
	1	Information address duplication is checked only within confines of a particular object type (DI/AI/DO/AO). Objects of different types are allowed to reuse same information addresses. Error message will be generated and objects of a particular type will be purged if address duplication is detected.

3.1.2 LinkSettings attributes

Link layer settings can be specified using attributes of [LinkSettings](#) element node.

Please see sample [LinkSettings](#) node and the table listing all available attributes below.

```
<LinkSettings LinkAddrSize="1"
  ACDLinkStatusResp="0"
  ACDAAlways="0"
  FCBMaskLinkReq="0"
  TxAllVarLength="0"
  SingleCharACK="1" />
```

Table 3.3 IEC 60807-5-101 Slave LinkSettings attributes

Attribute	Values or range	Description
LinkAddrSize	1 or 2	Link layer address size in bytes (default 1 byte) Please note link address size of the protocol instances sharing the same hardware node must be the same.
ACDLinkStatusResp	0	ACD bit (of the link control field) value for 'status of link' response message (no access demand) (default value)
	1	ACD bit (of the link control field) value for 'status of link' response message (access demand)
ACDAAlways	0	ACD bit (of the link control field) in response messages is set only if Class 1 data is available (default value)
	1	ACD bit (of the link control field) in response messages is always set
FCBMaskLinkReq	0	FCB bit (of the link control field) must be zero in 'status of link' request received from Master station (default value)
	1	FCB bit (of the link control field) is ignored in 'status of link' request received from Master station
TxAllVarLength	0	Send variable and fixed length link layer messages as required (default value) (Variable link layer messages start with 0x68 and fixed length messages start with 0x10)
	1	Send only variable length link layer messages
SingleCharACK	0	Don't use single character (0xE5 and 0xA2) ACK and NACK responses (default value)
	1	Use single character (0xE5 and 0xA2) ACK and NACK responses

3.1.3 CommsSettings attributes

Communication state change behavior and related delays can be specified using attributes of [CommsSettings](#) element node.

Please see sample [CommsSettings](#) node and the table listing all available attributes below.

```
<CommsSettings OfflineDelay="120" StartupGIDelay="10" />
```

Table 3.4 IEC 60807-5-101 Slave CommsSettings attributes

Attribute	Values or range	Description
OfflineDelay	$1 \dots 2^{32} - 1$	Delay in seconds before resetting the link in case there is no request from Master station. Reset remote link message is required after communication loss longer than a configured offline delay in order to restore communication (default 60 seconds)
StartupGIDelay	$0 \dots 2^{32} - 1$	General interrogation commands are rejected for a configured number of seconds on system startup. Negative response will be generated if General interrogation command is received within this delay. Delay is designed to allow leandc firmware acquire data from outstations before reporting upstream (default value 0)

3.1.4 ASDUSettings attributes

Application layer settings can be specified using attributes of [ASDUSettings](#) element node.

Please see sample [ASDUSettings](#) node and the table listing all available attributes below.

```
<ASDUSettings COTSize="1"
  CAASize="1"
  IOASize="2"
  TimeSync="1"
  InvalidEvent="1"
  SUthroughoutDST="1"
  DIEventType="2"
  AIEventType="14"
  TranspTypes="1" />
```

Table 3.5 IEC 60807-5-101 Slave ASDUSettings attributes

Attribute	Values or range	Description
COTSize	1 or 2	Cause Of Transmission size in bytes including Originator address (default 1 byte, if originator address is not used)
CAASize	1 or 2	Common address of ASDU size in bytes (default 1 byte)
IOASize	1; 2 or 3	Information Object Address size in bytes (default 2 bytes)
TimeSync	0	Reject incoming clock synchronization messages (default value)
	1	Accept incoming clock synchronization messages and synchronize internal real time clock
InvalidEvent	0	Events with set Invalid [IV] bit will not be generated
	1	Events with set Invalid [IV] bit will be generated (default value)
SUthroughoutDST	0	Summer Time [SU] bit in any outgoing message timestamp will be set to indicate last hour of the summer time before clock adjustment at the end of DST (clock change one hour back) (default value)
	1	Summer Time [SU] bit in any outgoing message timestamp will always be set if date and time of the timestamp is Summer time. <i>Please note this functionality is deviation from communication standard and option should be avoided.</i>
DIEventType	See table 5.3	Use this ASDU type to send DI events which don't have DI.TypeID attribute specified in their element node. This setting also affects ASDU type of the static data (e.g. Single or Double status information) being reported to General interrogation request. (default value 2 – 'Single-point Information', DI event will be sent using ASDU type 2 [M_SP_TA_1], CP24time2A , msec and min)
AIEventType	See table 5.7	Use this ASDU type to send AI events which don't have AI.TypeID attribute specified in their element node. This setting also affects ASDU type of the static data (e.g. Normalized, Scaled, Short floating point) being reported to General interrogation request. (default value 14 – 'Short floating point', AI event will be sent using ASDU type 14 [M_ME_TC_1], CP24time2A , msec and min)

Continued on next page

Table 3.5 – continued from previous page

Attribute	Values or range	Description
TranspTypes	0	ASDU type to be used for each DI/AI object reporting upstream will be determined by XML configuration settings. (default value)
	1	ASDU type to be used for each DI/AI object reporting upstream will be made transparent whenever possible. Normally ASDU type of each individual object received from downstream outstation will be used to report this object upstream, providing both particular communication protocol instances are compatible. Otherwise default ASDU type will be used. Please note object will be excluded from General Interrogation responses before it is received from downstream outstation, as its type is not yet known.

3.1.5 Timeouts attributes

Timeout values can be specified using attributes of [Timeouts](#) element node.

Please see sample [Timeouts](#) node and the table listing all available attributes below.

```
<Timeouts Application="30" Command="10" Select="30" />
```

Table 3.6 IEC 60807-5-101 Slave Timeouts attributes

Attribute	Values or range	Description
Application	$1 \dots 2^{32} - 1$	Application timeout is a delay in seconds for how long communication protocol instance waits response from the destination (e.g. downstream station) after it has forwarded the control command received from an upstream Master station. If no response is received within a configured timeout, command is considered to be failed and communication protocol instance generates negative response to the upstream Master station. In general application timeout is used to terminate pending control commands, if communication to the destination (e.g. downstream station) is lost. (default 30 seconds)
Command	$1 \dots 2^{32} - 1$	Command timeout is a delay in seconds for how long communication protocol instance attempts to send command response to the upstream Master station. If it is impossible to send a response within a configured timeout, command is considered to be failed and processing is terminated (command gets removed from the buffer). In general command timeout is used to terminate pending control commands, if communication to the upstream Master station is lost. (default 10 seconds)
Select	$1 \dots 2^{32} - 1$	Select timeout is a maximal delay in seconds between received Select and Execute commands. If an Execute command is not received within a configured timeout, command is automatically de-selected, Execute command will not be accepted and new Select command is required. In general Select timeout is used to test reliability of the communication channel before executing control commands to prevent major delays due to intermittent communications (default 30 seconds)

3.1.6 TimeSettings attributes

Time settings of each communication protocol instance can be specified using attributes of [TimeSettings](#) element node.

Please see sample [TimeSettings](#) node and the table listing all available attributes below.

```
<TimeSettings TimeZone="Europe/Riga" />
```

Table 3.7 IEC 60807-5-101/104 Slave TimeSettings attributes

Attribute	Values or range	Description
TimeZone	Max 200 chars	Adjust incoming and outgoing message timestamps assuming peer station operates within the specified time zone. TimeZone attribute must not be used if not required, there is no default value. Message timestamps will not be adjusted if attribute omitted. Please see Time Zone specification for additional information.

3.1.7 Periodic attributes

Periodic intervals of sending various messages can be specified using attributes of [Periodic](#) element node. Please see sample [Periodic](#) node and the table listing all available attributes below.

```
<Periodic AI="60" />
```

Table 3.8 IEC 60807-5-101 Slave Periodic attributes

Attribute	Values or range	Description
AI	$0 \dots 2^{32} - 1$	Periodic analogue value reporting interval in seconds. Value 0 disables periodic analog value reporting (default value 0)

3.1.8 BufferSizes attributes

Various communication buffer sizes and can be specified using attributes of [BufferSizes](#) element node.

Please see sample [BufferSizes](#) node and the table listing all available attributes below.

```
<BufferSizes DIEvent="1024" AIEvent="1024" DO="1" ASDUTx="253" />
```

Table 3.9 IEC 60807-5-101 Slave BufferSizes attributes

Attribute	Values or range	Description
DIEvent	1...65535	DI event buffer size, number of entries. Communication protocol instances use designated buffers to store events before they are reported upstream. This prevents information loss in case of a communication failure. Oldest events are getting discarded to empty space for new events when buffer overflows. (default value 0 – automatic size) <i>By default buffer size is automatically initialized twice the amount of configured DI objects, which is sufficient for most applications.</i>
AIEvent	1...65535	AI event buffer size, number of entries. Communication protocol instances use designated buffers to store events before they are reported upstream. This prevents information loss in case of a communication failure. Oldest events are getting discarded to empty space for new events when buffer overflows. (default value 0 – automatic size) <i>By default buffer size is automatically initialized twice the amount of configured AI objects, which is sufficient for most applications.</i>
DO	1...255	Control command buffer size in entries. Communication protocol instances use designated buffer to hold received control commands until command execution is completed. It is possible to create a queue, where commands are executed sequentially one after another. Set DO greater than 1 in order to enable this feature. (default value 1; only one control command will be processed at a time. New command received before previous command execution is complete will be rejected)
ASDUTx	14...253	Application layer transmission buffer size in bytes. Maximal length of message transmitted over IEC 60870-5-101 communication link is 255 bytes. Considering the link layer framing, maximal size of the application layer is 253 bytes, providing size of the link address is 1 byte and 252 if size of the link address is 2 bytes. This attribute allows to limit maximal length of a transmitted message (default value 253)

IEC60870-5-104 Slave configuration

This section describes how to configure IEC 60870-5-104 controlled station (Slave) communication protocol instance. Each IEC 60870-5-104 controlled station (Slave) communication protocol instance must have XML configuration file where its IO object table and additional protocol-related settings will be stored. One and the same XML configuration file can be used for multiple IEC 60870-5-104 controlled station (Slave) communication protocol instances, this becomes useful in case if identical IO objects need to be reported to several Master stations.

Name and location path of the XML configuration file are not predefined, they can be chosen freely. File name 'IEC104sl_test.xml' will be used as a sample and location path doesn't need to be specified if XML file is stored in the same directory as leandc firmware. In order to use the XML file for a communication protocol instance, simply enter the name 'IEC104sl_test.xml' in the [IEC104sl.XMLpath](#) attribute.

IEC60870-5-104 Slave configuration file (e.g. 'IEC104sl_test.xml') must have a root object node [IEC104slConfig](#) which has 6 child group object nodes [VersionControl](#); [ProtocolCfg](#); [DITable](#); [AITable](#); [DOTable](#); [AOTable](#) please see the sample below.

```
<IEC104slConfig xmlns="http://www.londelec.com/xmlschemas/leandc/IEC104sl" ... version="1.00">
  <VersionControl conf="4" date="2014-01-18" time="10:08:09"/>
  <ProtocolCfg>
    <XMLSettings IOAOverlap="1" />
    <CommsSettings OfflineDelay="120" />
    ...
  </ProtocolCfg>
  <DITable>
    <DI Device="10" Index="0" InfAddr="1" qualifier="0x10"/>
    ...
  </DITable>
  <AITable>
    <AI Device="10" Index="0" InfAddr="10" qualifier="0x00" Coeff="1.0"/>
    ...
  </AITable>
  <DOTable>
    <DO Device="10" Index="0" InfAddr="1"/>
    ...
  </DOTable>
  <AOTable>
    <AO Device="10" Index="0" InfAddr="1"/>
    ...
  </AOTable>
</IEC104slConfig>
```

[DITable](#); [AITable](#); [DOTable](#); [AOTable](#) group nodes compose an IO object table and they are common for IEC60870-5-101 and IEC60870-5-104 controlled station (Slave) communication protocol instances. Please refer to the tables [5.1](#); [5.5](#); [5.9](#) and [5.13](#) for their attributes.

4.1 ProtocolCfg group node

Protocol-related settings of the IEC60870-5-104 controlled station (Slave) communication protocol instance are configured using various child element nodes under [ProtocolCfg](#) group node.

Important:

It is essential to keep element nodes in the listed order otherwise it will affect the XML file validation.

Please see sample [ProtocolCfg](#) group node and the table listing all available child element nodes below.

```
<ProtocolCfg>
  <XMLSettings ... />
  <TransportSettings ... />
  <CommsSettings ... />
  <ASDUSettings ... />
  <Timeouts ... />
  <TimeSettings ... />
  <Periodic ... />
  <BufferSizes ... />
  <Miscellaneous ... />
</ProtocolCfg>
```

Tip:

All element nodes are optional, default values will be used for attributes of omitted nodes.

Table 4.1 IEC 60807-5-104 Slave ProtocolCfg child element nodes

Attribute	Values or range	Description
XMLSettings	See table 4.2	XML parse setting specification node. Refer to table 4.2 for attribute specification.
TransportSettings	See table 4.3	Communication transport interface timeout and message window size configuration node. Refer to table 4.3 for attribute specification.
CommsSettings	See table 4.4	Communication status (e.g. online and offline) change behavior and related delay configuration node. Refer to table 4.4 for attribute specification.
ASDUSettings	See table 4.5	Various application layer settings configuration node. Refer to table 4.5 for attribute specification.
Timeouts	See table 4.6	Control command expiration timeout configuration node. Refer to table 4.6 for attribute specification.
TimeSettings	See table 4.7	Unique time settings (e.g. time zone) of particular protocol instance. Refer to table 4.7 for attribute specification.
Periodic	See table 4.8	Periodically generated message configuration node. Refer to table 4.8 for attribute specification.
BufferSizes	See table 4.9	Various application layer buffer size configuration node. Refer to table 4.9 for attribute specification.
Miscellaneous	See table 4.10	Miscellaneous and project-specific setting configuration node. Refer to table 4.10 for attribute specification.

4.1. ProtocolCfg group node

4.1.1 XMLSettings attributes

XML file parse settings such as information object address validation can be specified using attributes of [XMLSettings](#) element node.

Please see sample [XMLSettings](#) node and the table listing all available attributes below.

```
<XMLSettings IOAOverlap="1" />
```

Table 4.2 IEC 60807-5-104 Slave XMLSettings attributes

Attribute	Values or range	Description
IOAOverlap	0	Each information object (DI/AI/DO/AO) specified in an IO table must have unique information object address (IOA). Error message will be generated and IO object table will be purged if address duplication is detected. (default value)
	1	Information address duplication is checked only within confines of a particular object type (DI/AI/DO/AO). Objects of different types are allowed to reuse same information addresses. Error message will be generated and objects of a particular type will be purged if address duplication is detected.

4.1.2 TransportSettings attributes

Protocol transport interface settings can be specified using attributes of [TransportSettings](#) element node.

Please see sample [TransportSettings](#) node and the table listing all available attributes below.

```
<TransportSettings T1="15" T2="10" T3="20" Kparam="12" Wparam="8" />
```

Table 4.3 IEC 60807-5-104 Slave XMLSettings attributes

Attribute	Values or range	Description
T1	1...65535	Timeout of send or test APDUs as per IEC 60870-5-104 standard. It is a delay in seconds for how long communication protocol instance waits a reply to a sent APDU [I-frame] or test message [TESTFR_act]. If no reply is received from peer station within a configured timeout, communication protocol instance initiates active close of the TCP socket (default 15 seconds)
T2	1...65535	Timeout for acknowledges in case of no data messages as per IEC 60870-5-104 standard. (requirement: T2timer < T1timer) It is a delay in seconds before communication protocol instance sends an acknowledge [S-frame] in case there are any unacknowledged messages from the peer station. (default 10 seconds)
T3	1...65535	Timeout for sending test messages in case of a long idle state from IEC 60870-5-104 standard. It is a maximal idle time in seconds before a test message [TESTFR_act] is sent to a peer station by the communication protocol instance. If this timeout is selected greater than T3 timeout configured in the peer station, it is most likely the test message will be sent by the peer station first (default 20 seconds)
Kparam	1...30	Maximum difference receive sequence number to send state variable as per IEC 60870-5-104 standard. Maximal number of outgoing APDU messages [I-frames] communication protocol instance will send to a peer station before it waits for an acknowledge [S-frame] (default 12 APDU messages)
Wparam	1...29	Latest acknowledge after receiving w number I format APDUs as per IEC 60870-5-104 standard. Number of incoming APDU messages [I-frames] received from a peer station before communication protocol instance sends an acknowledge [S-frame] (default 8 APDU messages)

4.1. ProtocolCfg group node

4.1.3 CommsSettings attributes

Communication state change behavior and related delays can be specified using attributes of [CommsSettings](#) element node.

Please see sample [CommsSettings](#) node and the table listing all available attributes below.

```
<CommsSettings OfflineDelay="10" StartupGIDelay="10" />
```

Table 4.4 IEC 60807-5-104 Slave CommsSettings attributes

Attribute	Values or range	Description
OfflineDelay	$1 \dots 2^{32} - 1$	Offline delay in seconds before outstation status is changed to OFFLINE. Offline delay timer is activated after TCP socket has been closed. Default 0 seconds - outstation status will be changed to OFFLINE immediately after TCP socket has been closed by either peer (default 0 seconds)
StartupGIDelay	$0 \dots 2^{32} - 1$	General interrogation commands are rejected for a configured number of seconds on system startup. Negative response will be generated if General interrogation command is received within this delay. Delay is designed to allow leandc firmware acquire data from outstations before reporting upstream (default value 0)

4.1.4 ASDUSettings attributes

Application layer settings can be specified using attributes of [ASDUSettings](#) element node.

Please see sample [ASDUSettings](#) node and the table listing all available attributes below.

```
<ASDUSettings InvalidEvent="1"
  SUthroughtoutDST="1"
  DIEventType="31"
  AIEventType="36"
  TranspTypes="1" />
```

Table 4.5 IEC 60807-5-104 Slave ASDUSettings attributes

Attribute	Values or range	Description
InvalidEvent	0	Events with set Invalid [IV] bit will not be generated
	1	Events with set Invalid [IV] bit will be generated (default value)
SUthroughtoutDST	0	Summer Time [SU] bit in any outgoing message timestamp will be set to indicate last hour of the summer time before clock adjustment at the end of DST (clock change one hour back) (default value)
	1	Summer Time [SU] bit in any outgoing message timestamp will always be set if date and time of the timestamp is Summer time. <i>Please note this functionality is deviation from communication standard and option should be avoided.</i>
DIEventType	See table 5.3	Use this ASDU type to send DI events which don't have DI.TypeID attribute specified in their element node. This setting also affects ASDU type of the static data (e.g. Single or Double status information) being reported to General interrogation request. (default value 30 – 'Single-point Information', DI event will be sent using ASDU type 30 [M_SP_TB_1], CP56time2A , full time)
AIEventType	See table 5.7	Use this ASDU type to send AI events which don't have AI.TypeID attribute specified in their element node. This setting also affects ASDU type of the static data (e.g. Normalized, Scaled, Short floating point) being reported to General interrogation request. (default value 36 – 'Short floating point', AI event will be sent using ASDU type 36 [M_ME_TF_1], CP56time2A , full time)
TranspTypes	0	ASDU type to be used for each DI/AI object reporting upstream will be determined by XML configuration settings. (default value)
	1	ASDU type to be used for each DI/AI object reporting upstream will be made transparent whenever possible. Normally ASDU type of each individual object received from downstream outstation will be used to report this object upstream, providing both particular communication protocol instances are compatible. Otherwise default ASDU type will be used. <i>Please note object will be excluded from General Interrogation responses before it is received from downstream outstation, as its type is not yet known.</i>

Continued on next page

Table 4.5 – continued from previous page

Attribute	Values or range	Description
CommandLatency	$0 \dots 2^{32} - 1$	Maximal difference in seconds between timestamp of the received time-tagged control command and internal time. Incoming control command timestamp is being validated and command gets discarded if it has been substantially delayed in the communication channel while being received. Value 0 disables timestamp validation and any incoming control command will be accepted (default value 0)

4.1.5 Timeouts attributes

Timeout values can be specified using attributes of [Timeouts](#) element node.

Please see sample [Timeouts](#) node and the table listing all available attributes below.

```
<Timeouts Application="30" Command="10" Select="30" />
```

Table 4.6 IEC 60807-5-104 Slave Timeouts attributes

Attribute	Values or range	Description
Application	$1 \dots 2^{32} - 1$	Application timeout is a delay in seconds for how long communication protocol instance waits response from the destination (e.g. downstream station) after it has forwarded the control command received from an upstream Master station. If no response is received within a configured timeout, command is considered to be failed and communication protocol instance generates negative response to the upstream Master station. In general application timeout is used to terminate pending control commands, if communication to the destination (e.g. downstream station) is lost. (default 30 seconds)
Command	$1 \dots 2^{32} - 1$	Command timeout is a delay in seconds for how long communication protocol instance attempts to send command response to the upstream Master station. If it is impossible to send a response within a configured timeout, command is considered to be failed and processing is terminated (command gets removed from the buffer). In general command timeout is used to terminate pending control commands, if communication to the upstream Master station is lost. (default 10 seconds)
Select	$1 \dots 2^{32} - 1$	Select timeout is a maximal delay in seconds between received Select and Execute commands. If an Execute command is not received within a configured timeout, command is automatically de-selected, Execute command will not be accepted and new Select command is required. In general Select timeout is used to test reliability of the communication channel before executing control commands to prevent major delays due to intermittent communications (default 30 seconds)

4.1.6 TimeSettings attributes

Time settings of each communication protocol instance can be specified using attributes of [TimeSettings](#) element node.

Please see sample [TimeSettings](#) node and the table listing all available attributes below.

```
<TimeSettings TimeZone="Europe/Riga" />
```

Table 4.7 IEC 60807-5-101/104 Slave TimeSettings attributes

Attribute	Values or range	Description
TimeZone	Max 200 chars	Adjust incoming and outgoing message timestamps assuming peer station operates within the specified time zone. TimeZone attribute must not be used if not required, there is no default value. Message timestamps will not be adjusted if attribute omitted. Please see Time Zone specification for additional information.

4.1.7 Periodic attributes

Periodic intervals of sending various messages can be specified using attributes of [Periodic](#) element node. Please see sample [Periodic](#) node and the table listing all available attributes below.

```
<Periodic AI="60" />
```

Table 4.8 IEC 60807-5-104 Slave Periodic attributes

Attribute	Values or range	Description
AI	$0 \dots 2^{32} - 1$	Periodic analogue value reporting interval in seconds. Value 0 disables periodic analog value reporting (default value 0)

4.1.8 BufferSizes attributes

Various communication buffer sizes and can be specified using attributes of [BufferSizes](#) element node.

Please see sample [BufferSizes](#) node and the table listing all available attributes below.

```
<BufferSizes DIEvent="1024" AIEvent="1024" DO="1" ASDUTx="253" />
```

Table 4.9 IEC 60807-5-104 Slave BufferSizes attributes

Attribute	Values or range	Description
DIEvent	1...65535	DI event buffer size, number of entries. Communication protocol instances use designated buffers to store events before they are reported upstream. This prevents information loss in case of a communication failure. Oldest events are getting discarded to empty space for new events when buffer overflows. (default value 0 – automatic size) <i>By default buffer size is automatically initialized twice the amount of configured DI objects, which is sufficient for most applications.</i>
AIEvent	1...65535	AI event buffer size, number of entries. Communication protocol instances use designated buffers to store events before they are reported upstream. This prevents information loss in case of a communication failure. Oldest events are getting discarded to empty space for new events when buffer overflows. (default value 0 – automatic size) <i>By default buffer size is automatically initialized twice the amount of configured AI objects, which is sufficient for most applications.</i>
DO	1...255	Control command buffer size in entries. Communication protocol instances use designated buffer to hold received control commands until command execution is completed. It is possible to create a queue, where commands are executed sequentially one after another. Set DO greater than 1 in order to enable this feature. (default value 1; only one control command will be processed at a time. New command received before previous command execution is complete will be rejected)

4.1.9 Miscellaneous attributes

Miscellaneous and project-specific settings can be specified using attributes of [Miscellaneous](#) element node.

Please see sample [Miscellaneous](#) node and the table listing all available attributes below.

```
<Miscellaneous LegacyAIEVinitdelay="20" />
```

Table 4.10 IEC 60807-5-104 Slave Miscellaneous attributes

Attribute	Values or range	Description
LegacyAIEVinitdelay	$0 \dots 2^{32} - 1$	Attribute enables specially marked (legacy spontaneous-only) AI object post-initialization after configured number of seconds when downstream outstation goes online. This functionality is enabled for AI objects which have Legacy bit [2] set in Master's AI.qualifier . If an AI has Invalid [IV] bit set, its Invalid [IV] bit will be cleared and object will be sent upstream after number of seconds configured in LegacyAIEVinitdelay on system startup and whenever downstream outstation goes online. AI value will remain unchanged, being 0 on system startup and previous value from internal database when outstation goes online.

IEC60870-5-101/104 Slave IO object table

This section describes how to configure IO object table for IEC 60870-5-101 and IEC 60870-5-104 controlled station (Slave) communication protocol instance. Group object nodes [DITable](#); [AITable](#); [DOTable](#); [AOTable](#) are included in XML configuration files of the IEC60870-5-101 and IEC60870-5-104 controlled station (Slave) communication protocol instances as described in previous sections **IEC60870-5-101 Slave configuration** and **IEC60870-5-104 Slave configuration**.

5.1 DITable group and DI node

Group node [DITable](#) and child element nodes [DI](#) are used to create DI information objects to send static status information and status change events to the upstream Master station. Each created DI information object needs to have a source of information. The source is created by linking DI information object to a [DI](#) node of any Master protocol instance that is defined in leandc. (Master protocol instances are defined under [CommunicationCfg](#) node in **leandc.xml** file)

The link is created using [DI.Device](#) and [DI.Index](#) attributes. The first step is to select the **source Master protocol instance**, use value of the [Index](#) attribute of any Master protocol instance. The next step is to select the **source DI object**, use value of the [DI.Index](#) attribute of any DI object listed in the IO object table of a Master protocol instance. Enter the selected values of **source Master protocol instance** in [DI.Device](#) attribute and **source DI object** in [DI.Index](#) attribute.

Information address (IOA) for sending DI information object upstream is entered in [DI.InfAddr](#) attribute.

Please see sample [DITable](#) group node and [DI](#) child element nodes below. There are 5 DI information objects configured using 4 [DI](#) element nodes.

```
<DITable>
  <DI Device="10" Index="0" InfAddr="1" qualifier="0" GroupMask="0x0001" ... />
  <DI Device="10" Index="1" InfAddr="2" qualifier="0x10" TypeID="30" ... />
  <DI Device="10" Index="-2" InfAddr="3" qualifier="0x00" TypeID="30" ... />
  <DI Device="10" Index="2" InfAddr="4" qualifier="0x00" Total="2" ... />
</DITable>
```

Please see sample [DI](#) element node below listing all available attributes.

```
<DI Device="10"
  Index="0"
  InfAddr="1"
  qualifier="0"
  GroupMask="0x0001"
  TypeID="30"
  Total="2"
  Name="CB position" />
```

Tip:

Attributes of the [DI](#) element node can be arranged in any order, it will not affect the XML file validation.

5.1.1 DI attributes

Table 5.1 IEC 60807-5-101/104 Slave DI attributes

Attribute	Values or range	Description
Device	1...254	Source communication protocol instance. Any Master protocol instance listed in CommunicationCfg group can be used as a source. Use value of the Master protocol instance Index attribute in order to link DI to it. <i>Attribute is optional and doesn't have to be included in configuration, value of the IEC101sl.Source or IEC104sl.Source attributes will be used if omitted.</i>
Index	-8...2 ³² - 8	Source DI object. Any DI element node of the selected Master protocol instance can be used as a source. Use value of the DI.Index attribute of any DI object listed in the IO table of the selected Master protocol instance. Apart from regular indexes, there are some Service index values available, those are designed to monitor the status of the linked Master protocol instance. Service index values are summarized in the table 5.4 . <i>Indexes don't have to be arranged in an ascending order.</i>
InfAddr	1...16777215	Information Object Address (IOA) of the DI object. This IOA will be used to send object to upstream Master station. <i>Addresses don't have to be arranged in an ascending order.</i>
qualifier	See table 5.2 for description	Internal object qualifier to enable customized data processing. See table 5.2 for internal object qualifier description. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
GroupMask	0...0xFFFF	Include object in Interrogation group/groups. Each bit of the group mask attribute needs to be set in order to include object in a particular interrogation group. Please refer to the table 5.8 for more information. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
TypeID	See table 5.3 for description	Use this ASDU Type to send a DI event. Attribute also affects ASDU type of the static data (e.g. Single or Double status information) being reported to General interrogation request (default value depends on the protocol type, refer to table 5.3). <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Total	1...16777215	Total number of information objects. Attribute is used to create sequence of information objects with consecutive DI.Index and DI.InfAddr attribute values without a need to create individual DI nodes for each information object. (default value 1; only 1 object is created with this DI node) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Name	Max 100 chars	Freely configurable name, just for reference. <i>Name attribute is optional and doesn't have to be included in configuration.</i>

5.1.2 DI.qualifier

Table 5.2 IEC 60807-5-101/104 Slave DI internal qualifier

Bits	Values	Description
qualifier [xxxx.xxxx]	0...0xFF	DI internal qualifier has 8 data bits
Bit 0	xxxx.xxx0	DI object will not be inverted (ON = 1; OFF = 0 for [M_SP_NA_1] type and ON = 2; OFF = 1; INTER = 0; INVALID = 3 for [M_DP_NA_1] type)
	xxxx.xxx1	DI object will be inverted (ON = 0; OFF = 1 for [M_SP_NA_1] type and ON = 1; OFF = 2; INTER = 0; INVALID = 3 for [M_DP_NA_1] type)
Bit 1	xxxx.xx0x	Additional 'Zero' DI event generation disabled
	xxxx.xx1x	Additional 'Zero' DI event generation enabled . An OFF event will be internally generated following every sent DI ON event. DI object will always have OFF value in Interrogation responses.
Bit 2	xxxx.x0xx	DI events enabled . DI event will be sent upstream if state of the object changes or new event is received from the source communication protocol instance
	xxxx.x1xx	DI events disabled
Bit 3	xxxx.0xxx	DI object will be included in General Interrogation response
	xxxx.1xxx	DI object will be excluded from General Interrogation response
Bit 6	x0xx.xxxx	All DI events will be sent upstream
	x1xx.xxxx	DI events with OFF values or with set [IV] bit will be discarded. <i>This option is only used for backward compatibility.</i>
Bit 7	0xxx.xxxx	DI is enabled and will be sent upstream
	1xxx.xxxx	DI is disabled and will not be sent upstream
Bits 4;5	Any	Bits reserved for future use

5.1.3 DI.TypeID

Table 5.3 IEC 60870-5-101/104 Slave DI TypeID

TypeID Value for IEC60870-5-101	TypeID Value for IEC60870-5-104	Description
1	1	Static DI 'Single-point Information' will be sent using ASDU type 1 [M_SP_NA_1] DI event will be sent using ASDU type 1 [M_SP_NA_1], no time-tag
2	N/A	Static DI 'Single-point Information' will be sent using ASDU type 1 [M_SP_NA_1] DI event will be sent using ASDU type 2 [M_SP_TA_1], CP24time2A , msec and min
3	3	Static DI 'Double-point Information' will be sent using ASDU type 3 [M_DP_NA_1] DI event will be sent using ASDU type 3 [M_DP_NA_1], no time-tag
4	N/A	Static DI 'Double-point Information' will be sent using ASDU type 3 [M_DP_NA_1] DI event will be sent using ASDU type 4 [M_DP_TA_1], CP24time2A , msec and min
30	30	Static DI 'Single-point Information' will be sent using ASDU type 1 [M_SP_NA_1] DI event will be sent using ASDU type 30 [M_SP_TB_1], CP56time2A , full time
31	31	Static DI 'Double-point Information' will be sent using ASDU type 3 [M_DP_NA_1] DI event will be sent using ASDU type 31 [M_DP_TB_1], CP56time2A , full time
Other	Other	Undefined, default values will be used: IEC 60870-5-101 default ASDU type 2 [M_SP_TA_1], CP24time2A , msec and min IEC 60870-5-104 default ASDU type 30 [M_SP_TB_1], CP56time2A , full time

Tip:

Note, all DI objects are internally stored and processed as 'Double-point status information'. If 'Single-point status information' type needs to be reported to the upstream Master station, object is being converted just before it is sent.

5.1.4 DI Service Indexes

There are some Service DI indexes available allowing to monitor real-time operational status of the communication protocol instances. These indexes have negative decimal values allowing then to be easily distinguished from regular indexes used for linking.

Table 5.4 IEC 60807-5-101/104 Slave Service DI indexes

Index value	Object value	Description
-2 (0xFFFFFFFFFE)	ON	Communication between leandc and peer station is running, peer station is Online . This service index can be used for any protocol instance.
	OFF	Communication between leandc and peer station is lost, peer station is Offline . This service index can be used for any protocol instance.
-3 (0xFFFFFFFFFD)	ON	Communication between leandc and peer station is Enabled . This service index can be used for any protocol instance.
	OFF	Communication between leandc and peer station is Disabled . This service index can be used for any protocol instance.
-4 (0xFFFFFFFFFC)	ON	Only applicable to IEC60870-5-104 Master/Slave protocol instances; communication is in a [Started] state, [STARTDT_act] message is sent and [STARTDT_con] message is received.
	OFF	Only applicable to IEC60870-5-104 Master/Slave protocol instances; communication is in a [Stopped] state, [STARTDT_act] message hasn't been sent or [STOPPED_act] message hasn't been received.
-5 (0xFFFFFFFFFB)	ON	Only used for protocol instances linked to UART hardware node; State of the UART Ring Indicator RI pin(9) is active (+12V) . This service DI can be used only if UART.CtrlRdTimer attribute is defined.
	OFF	Only used for protocol instances linked to UART hardware node; State of the UART Ring Indicator RI pin(9) is not active (-12V) . This service DI can be used only if UART.CtrlRdTimer attribute is defined.
-1 and -6...-8	Any	Internal indications reserved for future use

5.2 AITable group and AI node

Group node [AITable](#) and child element nodes [AI](#) are used to create AI information objects to send static analogue values and analog events to the upstream Master station. Each created AI information object needs to have a source of information. The source is created by linking AI information object to an [AI](#) node of any Master protocol instance that is defined in leandc. (Master protocol instances are defined under [CommunicationCfg](#) node in **leandc.xml** file)

The link is created using [AI.Device](#) and [AI.Index](#) attributes. The first step is to select the **source Master protocol instance**, use value of the [Index](#) attribute of any Master protocol instance. The next step is to select the source AI object, use value of the [AI.Index](#) attribute of any AI object listed in the IO object table of a Master protocol instance. Enter the selected values of **source Master protocol instance** in [AI.Device](#) attribute and **source AI object** in [AI.Index](#) attribute.

Information address (IOA) for sending AI information object upstream is entered in [AI.Device](#) attribute.

Please see sample [AITable](#) group node and [AI](#) child element nodes below. There are 5 AI information objects configured using 4 [AI](#) element nodes.

```
<AITable>
  <AI Device="10" Index="0" InfAddr="1" qualifier="0x20" Coeff="1.0" Offset="28.0" ... />
  <AI Device="10" Index="1" InfAddr="2" qualifier="0x00" ZeroDeadband="1.0" ... />
  <AI Device="10" Index="2" InfAddr="3" qualifier="0x01" Coeff="0.05" GroupMask="0x0002" ... />
  <AI Device="10" Index="3" InfAddr="4" qualifier="0x00" Coeff="1.0" Offset="2.0" Total="2" ... />
</AITable>
```

Please see sample [AI](#) element node below listing all available attributes.

```
<AI Device="10"
  Index="2"
  InfAddr="3"
  qualifier="0"
  Coeff="100.0"
  StartOffset="6554"
  ZeroDeadband="5.0"
  Offset="-2.0"
  OffsetDeadband="2.0"
  NonZeroOffset="200.0"
  GroupMask="0x0002"
 TypeID="13"
  Total="2"
  Name="Feeder current" />
```

Tip:

Attributes of the [AI](#) element node can be arranged in any order, it will not affect the XML file validation.

5.2.1 AI attributes

Table 5.5 IEC 60807-5-101/104 Slave AI attributes

Attribute	Values or range	Description
Device	1...254	Source communication protocol instance. Any Master protocol instance listed in CommunicationCfg group can be used as a source. Use value of the Master protocol instance Index attribute in order to link AI to it. <i>Attribute is optional and doesn't have to be included in configuration, value of the IEC101sl.Source or IEC104sl.Source attributes will be used if omitted.</i>
Index	0...2 ³² - 1	Source AI object. Any AI element node of the selected Master protocol instance can be used as a source. Use value of the AI.Index attribute of any AI object listed in the IO table of the selected Master protocol instance. <i>Indexes don't have to be arranged in an ascending order.</i>
InfAddr	1...16777215	Information Object Address (IOA) of the AI object. This IOA will be used to send object to upstream Master station. <i>Addresses don't have to be arranged in an ascending order.</i>
qualifier	See table 5.6 for description	Internal object qualifier to enable customized data processing. See table 5.6 for internal object qualifier description. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Coeff	$\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Coefficient to multiply the analog object value before sending to upstream Master station. (default value 1) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
StartOffset*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Scale start offset to compensate e.g. 4-20mA transducer output range. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
ZeroDeadband*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Zero Deadband allows to filter noise by forcing small fluctuating AI values to 0. If an absolute value (+/-) of the received AI is less than ZeroDeadband attribute, AI value will be forced to 0. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Offset*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Offset AI value after ZeroDeadband has been applied. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
OffsetDeadband*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Offset Zero Deadband allows to filter noise around 0 value after applying Offset . If an absolute value (+/-) after offsetting is less than OffsetDeadband attribute, AI value will be forced to 0. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>

Continued on next page

Table 5.5 – continued from previous page

Attribute	Values or range	Description
NonZeroOffset*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Offset only non-zero values after ZeroDeadband ; Offset and OffsetDeadband has been applied. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
GroupMask	0...0xFFFF	Include object in Interrogation group/groups. Each bit of the group mask attribute needs to be set in order to include object in a particular interrogation group. Please refer to the table 5.8 for more information. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
TypeID	See table 5.7 for description	Use this ASDU Type to send a AI event. Attribute also affects ASDU type of the static data (e.g. Normalized, Scaled, Short floating point value) being reported to General interrogation request (default value depends on the protocol type, refer to table 5.7). <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Total	1...16777215	Total number of information objects. Attribute is used to create sequence of information objects with consecutive AI.Index and AI.InfAddr attribute values without a need to create individual AI nodes for each information object. (default value 1; only 1 object is created with this AI node) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Name	Max 100 chars	Freely configurable name, just for reference. <i>Name attribute is optional and doesn't have to be included in configuration.</i>

Tip:

* Please refer to annexes [AI scaling without StartOffset enabled](#) and [AI scaling with StartOffset enabled](#) for additional information on AI scaling and application examples using [AI.StartOffset](#) ; [AI.ZeroDeadband](#) ; [AI.Offset](#) ; [AI.OffsetDeadband](#) ; [AI.NonZeroOffset](#) attributes.

5.2.2 AI.qualifier

Table 5.6 IEC 60807-5-101/104 Slave AI internal qualifier

Bits	Values	Description
qualifier [xxxx.xxxx]	0...0xFF	AI internal qualifier has 8 data bits
Bit 0*	xxxx.xxx0	AI.StartOffset attribute will be used for AI scaling.
	xxxx.xxx1	Fixed offset (6554) will be loaded to AI.StartOffset attribute in order to compensate 4-20mA transducer output offset. Applies to positive or negative AI values.
Bit 1	xxxx.xx0x	Additional 'Zero' AI event generation disabled
	xxxx.xx1x	Additional 'Zero' AI event generation enabled . A value 0 event will be internally generated following every sent AI event sent with nonzero value. AI object will always have 0 value in interrogation responses.
Bit 2	xxxx.x0xx	AI events enabled . AI event will be sent upstream if event is received from the source communication protocol instance
	xxxx.x1xx	AI events disabled
Bit 3	xxxx.0xxx	AI object will be included in General Interrogation response
	xxxx.1xxx	AI object will be excluded from General Interrogation response
Bit 6	x0xx.xxxx	Send AI events upstream with their original value and use the same value for Interrogation response and periodic reporting
	x1xx.xxxx	Send AI events upstream with their original value, but use value 0 for Interrogation response and periodic reporting
Bit 7	0xxx.xxxx	AI is enabled and will be sent upstream
	1xxx.xxxx	AI is disabled and will not be sent upstream
Bits 4;5	Any	Bits reserved for future use

Tip:

* Please refer to annexes **AI scaling without StartOffset enabled** and **AI scaling with StartOffset enabled** for additional information on AI scaling and application examples using [AI.qualifier](#) Bit[0].

5.2.3 AI.TypeID

Table 5.7 IEC 60807-5-101/104 Slave AI TypeID

TypeID Value for IEC60870-5-101	TypeID Value for IEC60870-5-104	Description
5	5	Static 'Step position Information' will be sent using ASDU type 5 [M_ST_NA_1] AI event will be sent using ASDU type 5 [M_ST_NA_1], no time-tag
6	N/A	Static 'Step position Information' will be sent using ASDU type 5 [M_ST_NA_1] AI event will be sent using ASDU type 6 [M_ST_TA_1], CP24time2A , msec and min
9	9	Static 'Normalized Integer' will be sent using ASDU type 9 [M_ME_NA_1] AI event will be sent using ASDU type 9 [M_ME_NA_1], no time-tag
10	N/A	Static 'Normalized Integer' will be sent using ASDU type 9 [M_ME_NA_1] AI event will be sent using ASDU type 10 [M_ME_TA_1], CP24time2A , msec and min
11	11	Static 'Scaled Integer' will be sent using ASDU type 11 [M_ME_NB_1] AI event will be sent using ASDU type 11 [M_ME_NB_1], no time-tag
12	N/A	Static 'Scaled Integer' will be sent using ASDU type 11 [M_ME_NB_1] AI event will be sent using ASDU type 12 [M_ME_TB_1], CP24time2A , msec and min
13	13	Static 'Short floating point' will be sent using ASDU type 13 [M_ME_NC_1] AI event will be sent using ASDU type 13 [M_ME_NC_1], no time-tag
14	N/A	Static 'Short floating point' will be sent using ASDU type 13 [M_ME_NC_1] AI event will be sent using ASDU type 14 [M_ME_TC_1], CP24time2A , msec and min
32	32	Static 'Step position Information' will be sent using ASDU type 5 [M_ST_NA_1] AI event will be sent using ASDU type 32 [M_ST_TB_1], CP56time2A , full time
34	34	Static 'Normalized Integer' will be sent using ASDU type 9 [M_ME_NA_1] AI event will be sent using ASDU type 34 [M_ME_TD_1], CP56time2A , full time
35	35	Static 'Scaled Integer' will be sent using ASDU type 11 [M_ME_NB_1] AI event will be sent using ASDU type 35 [M_ME_TE_1], CP56time2A , full time
36	36	Static 'Short floating point' will be sent using ASDU type 13 [M_ME_NC_1] AI event will be sent using ASDU type 36 [M_ME_TF_1], CP56time2A , full time
Other	Other	Undefined, default values will be used: IEC 60870-5-101 default ASDU type 14 [M_ME_TC_1], CP24time2A , msec and min IEC 60870-5-104 default ASDU type 36 [M_ME_TF_1], CP56time2A , full time

Tip:

Note, all AI objects are internally stored and processed as 'Short floating point' values. If any other type needs to be reported to the upstream Master station, object is being converted just before it is sent.

5.3 DI/AI.GroupMask

Table 5.8 IEC 60807-5-101/104 Slave DI/AI GroupMask

Bits	Values	Description
GroupMask [xxxx.xxxx.xxxx.xxxx]	0...0xFFFF	GroupMask attribute has 16 data bits
Bit 0	xxxx.xxxx.xxxx.xxx0	DI/AI object is excluded from Group 1 Interrogation
	xxxx.xxxx.xxxx.xxx1	DI/AI object is included in Group 1 Interrogation
Bit 1	xxxx.xxxx.xxxx.xx0x	DI/AI object is excluded from Group 2 Interrogation
	xxxx.xxxx.xxxx.xx1x	DI/AI object is included in Group 2 Interrogation
Bit 2	xxxx.xxxx.xxxx.x0xx	DI/AI object is excluded from Group 3 Interrogation
	xxxx.xxxx.xxxx.x1xx	DI/AI object is included in Group 3 Interrogation
Bit 3	xxxx.xxxx.xxxx.0xxx	DI/AI object is excluded from Group 4 Interrogation
	xxxx.xxxx.xxxx.1xxx	DI/AI object is included in Group 4 Interrogation
Bit 4	xxxx.xxxx.xxxx0.xxxx	DI/AI object is excluded from Group 5 Interrogation
	xxxx.xxxx.xxxx1.xxxx	DI/AI object is included in Group 5 Interrogation
Bit 5	xxxx.xxxx.xx0x.xxxx	DI/AI object is excluded from Group 6 Interrogation
	xxxx.xxxx.xx1x.xxxx	DI/AI object is included in Group 6 Interrogation
Bit 6	xxxx.xxxx.x0xx.xxxx	DI/AI object is excluded from Group 7 Interrogation
	xxxx.xxxx.x1xx.xxxx	DI/AI object is included in Group 7 Interrogation
Bit 7	xxxx.xxxx.0xxx.xxxx	DI/AI object is excluded from Group 8 Interrogation
	xxxx.xxxx.1xxx.xxxx	DI/AI object is included in Group 8 Interrogation
Bit 8	xxxx.xxx0.xxxx.xxxx	DI/AI object is excluded from Group 9 Interrogation
	xxxx.xxx1.xxxx.xxxx	DI/AI object is included in Group 9 Interrogation
Bit 9	xxxx.xx0x.xxxx.xxxx	DI/AI object is excluded from Group 10 Interrogation
	xxxx.xx1x.xxxx.xxxx	DI/AI object is included in Group 10 Interrogation
Bit 10	xxxx.x0xx.xxxx.xxxx	DI/AI object is excluded from Group 11 Interrogation
	xxxx.x1xx.xxxx.xxxx	DI/AI object is included in Group 11 Interrogation
Bit 11	xxxx.0xxx.xxxx.xxxx	DI/AI object is excluded from Group 12 Interrogation
	xxxx.1xxx.xxxx.xxxx	DI/AI object is included in Group 12 Interrogation
Bit 12	xxx0.xxxx.xxxx.xxxx	DI/AI object is excluded from Group 13 Interrogation
	xxx1.xxxx.xxxx.xxxx	DI/AI object is included in Group 13 Interrogation
Bit 13	xx0x.xxxx.xxxx.xxxx	DI/AI object is excluded from Group 14 Interrogation
	xx1x.xxxx.xxxx.xxxx	DI/AI object is included in Group 14 Interrogation
Bit 14	x0xx.xxxx.xxxx.xxxx	DI/AI object is excluded from Group 15 Interrogation

Continued on next page

Table 5.8 – continued from previous page

Bits	Values	Description
	x1xx.xxxx.xxxx.xxxx	DI/AI object is included in Group 15 Interrogation
Bit 15	0xxx.xxxx.xxxx.xxxx	DI/AI object is excluded from Group 16 Interrogation
	1xxx.xxxx.xxxx.xxxx	DI/AI object is included in Group 16 Interrogation

Tip:

Value 0x0001 will include DI/AI object in Group1 Interrogation; value 0x0003 will include DI/AI object in Group1 and Group2 Interrogation, etc.

5.4 DOTable group and DO node

Group node [DOTable](#) and child element nodes [DO](#) are used to create DO information objects to receive control commands from the upstream Master station. Each created DO information object needs to have a destination to forward the control information. The destination is created by linking DO information object to a [DO](#) node of any Master protocol instance that is defined in leandc. (Master protocol instances are defined under [CommunicationCfg](#) node in **leandc.xml** file)

The link is created using [DO.Device](#) and [DO.Index](#) attributes. The first step is to select the **destination Master protocol instance**, use value of the [Index](#) attribute of any Master protocol instance. The next step is to select the **destination DO object**, use value of the [DO.Index](#) attribute of any DO object listed in the IO object table of any Master protocol instance. Enter the selected values of **destination Master protocol instance** in [DO.Device](#) attribute and **destination DO object** in [DO.Index](#) attribute.

Information address (IOA) for receiving control command is entered in [DO.InfAddr](#) attribute.

Please see sample [DOTable](#) group node and [DO](#) child element nodes below. There are 5 DO information objects configured using 4 [DO](#) element nodes.

```
<DOTable>
  <DO Device="10" Index="0" InfAddr="1" Policy="0" ... />
  <DO Device="10" Index="1" InfAddr="2" Policy="250" ... />
  <DO Device="10" Index="-2" InfAddr="3" Policy="0" ... />
  <DO Device="10" Index="2" InfAddr="4" Policy="0" Total="2" ... />
</DOTable>
```

Please see sample [DO](#) element node below listing all available attributes.

```
<DO Device="10"
  Index="2"
  InfAddr="4"
  qualifier="0x10"
  Policy="0"
 TypeID="0"
  OffIndex="33"
  Total="2"
  Name="CB command" />
```

Tip:

Attributes of the [DO](#) element node can be arranged in any order, it will not affect the XML file validation.

5.4.1 DO attributes

Table 5.9 IEC 60807-5-101/104 Slave DO attributes

Attribute	Values or range	Description
Device	1...254	Source communication protocol instance. Any Master protocol instance listed in CommunicationCfg group can be used as a source. Use value of the Master protocol instance Index attribute in order to link DO to it. Attribute is optional and doesn't have to be included in configuration, value of the IEC101sl.Source or IEC104sl.Source attributes will be used if omitted.
Index	-8...2 ³² - 8	Destination DO object. Any DO element node of the selected Master protocol instance can be used as a destination. Use value of the DO.Index attribute of any DO element node listed in the IO table of the selected Master protocol instance. Apart from regular indexes, there are some Service index values available, those are designed to control the linked Master protocol instance. Service index values are summarized in the table 5.12 . Indexes don't have to be arranged in an ascending order.
InfAddr	1...16777215	Information Object Address (IOA) of the DO object. This IOA will be used to receive command from upstream Master station. Addresses don't have to be arranged in an ascending order.
qualifier	See table 5.10 for description	Internal object qualifier to enable customized data processing. See table 5.10 for internal object qualifier description. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Policy	0...255	Command execution policy, see table 5.16 for description. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
TypeID	See table 5.11 for description	Only accept command if received with this ASDU Type. Value 0 disables incoming command ASDU type checking and any command is accepted. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
OffIndex	0...2 ³² - 1	Destination DO object for OFF command. Attribute allows to send ON and OFF commands to different destinations. Any DO element node of the selected Master protocol instance can be used as a destination. Use value of the DO.Index attribute of any DO element node listed in the IO table of the selected Master protocol instance. (default value is equal to DO.Index attribute) Attribute is optional and doesn't have to be included in configuration, both ON and OFF commands will be sent to the same destination object if this attribute is omitted.

Continued on next page

Table 5.9 – continued from previous page

Attribute	Values or range	Description
Total	1...16777215	Total number of information objects. Attribute is used to create sequence of information objects with consecutive DO.Index and DO.InfAddr attribute values without a need to create individual DO nodes for each information object. (default value 1; only 1 object is created with this DO node) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

5.4.2 DO.qualifier

Table 5.10 IEC 60807-5-101/104 Slave DO internal qualifier

Bits	Values	Description
qualifier [xxxx.xxxx]	0...0xFF	DO internal qualifier has 8 data bits
Bit 0	xxxx.xxx0	DO object will not be inverted
	xxxx.xxx1	DI object will be inverted (OFF → ON; ON → OFF)
Bits 6;5	x00x.xxxx	Only Direct-Execute commands are accepted
	x01x.xxxx	Direct-Execute and Select-before-Execute commands are accepted
	x10x.xxxx	Only Select-Before-Execute commands are accepted
	x11x.xxxx	Reserved for future use
Bit 7	0xxx.xxxx	DO is enabled and command will be processed when received
	1xxx.xxxx	DO is disabled and command will be rejected when received
Bits 1...4	Any	Bits reserved for future use

5.4.3 DO.TypeID

Table 5.11 IEC 60807-5-101/104 Slave DO TypeID

TypeID Value	Description
45	Only 'Single command' will be accepted and processed (ASDU type 45 [C_SC_NA_1])
46	Only 'Double command' will be accepted and processed (ASDU type 46 [C_DC_NA_1])
47	Only 'Regulating step command' will be accepted and processed (ASDU type 47 [C_RC_NA_1])
58	Only applicable to IEC60870-5-104 Slave protocol instance; Only time-tagged 'Single command' will be accepted and processed (ASDU type 58 [C_SC_TA_1])
59	Only applicable to IEC60870-5-104 Slave protocol instance; Only time-tagged 'Double command' will be accepted and processed (ASDU type 59 [C_DC_TA_1])
60	Only applicable to IEC60870-5-104 Slave protocol instance; Only time-tagged 'Regulating step command' will be accepted and processed (ASDU type 59 [C_RC_TA_1])
Other	Undefined, control command received with any ASDU type will be accepted

5.4.4 DO Service Indexes

There are some Service DO indexes available allowing to control operation of the Master protocol instance. These indexes have negative decimal values to easily separate them from regular indexes used for linking.

Table 5.12 IEC 60807-5-101/104 Slave Service DO indexes

Index value	Object value	Description
-2 (0xFFFFFFFFFE)	ON or OFF	Only applicable to Master communication protocol instances; Send forced Poll (e.g. General Interrogation) to downstream outstation.
-3 (0xFFFFFFFFFD)	ON	Enable leandc communication to peer station. This service index can be used for any protocol instance.
	OFF	Disable leandc communication to peer station. his service index can be used for any protocol instance.
-4 (0xFFFFFFFFFC)	ON	Only applicable to IEC60870-5-104 Master protocol instance; Start communication to downstream station by sending [STARTDT_act] message
	OFF	Only applicable to IEC60870-5-104 Master protocol instance; Stop communication to downstream station by sending [STOPDT_act] message
-5 (0xFFFFFFFFFB)	ON or OFF	Only applicable to Master communication protocol instances; Send Reset Process command (ASDU type 105 [C_RP_NA_1]) to downstream outstation
-1 and -6...-8	Any	Service commands reserved for future use

5.5 AOTable group and AO node

Group node [AOTable](#) and child element nodes [AO](#) are used to create AO information objects to receive setpoint commands from the upstream Master station. Each created AO information object needs to have a destination to forward the setpoint information. The destination is created by linking AO information object to a [AO](#) node of any Master protocol instance that is defined in leandc. (Master protocol instances are defined under [CommunicationCfg](#) node in **leandc.xml** file)

The link is created using [AO.Device](#) and [AO.Index](#) attributes. The first step is to select the **destination Master protocol instance**, use value of the [Index](#) attribute of any Master protocol instance. The next step is to select the **destination AO object**, use value of the [AO.Index](#) attribute of any AO object listed in the IO object table of any Master protocol instance. Enter the selected values of **destination Master protocol instance** in [AO.Device](#) attribute and destination AO object in [AO.Index](#) attribute.

Information address (IOA) for receiving setpoint command is entered in [AO.InfAddr](#) attribute.

Please see sample [AOTable](#) group node and [AO](#) child element nodes below. There are 5 AO information objects configured using 4 [AO](#) element nodes.

```
<AOTable>
  <AO Device="10" Index="0" InfAddr="1" Policy="0" ... />
  <AO Device="10" Index="1" InfAddr="2" Policy="250" ... />
  <AO Device="10" Index="-2" InfAddr="3" Policy="0" ... />
  <AO Device="10" Index="2" InfAddr="4" Policy="0" Total="2" ... />
</AOTable>
```

Please see sample [AO](#) element node below listing all available attributes.

```
<AO Device="10"
  Index="2"
  InfAddr="4"
  qualifier="0x80"
  Coeff="15.3"
  Policy="0"
 TypeID="0"
  Total="2"
  Name="Filtering value" />
```

Tip:

Attributes of the [AO](#) element node can be arranged in any order, it will not affect the XML file validation.

5.5.1 AO attributes

Table 5.13 IEC 60807-5-101/104 Slave AO attributes

Attribute	Values or range	Description
Device	1...254	Source communication protocol instance. Any Master protocol instance listed in CommunicationCfg group can be used as a source. Use value of the Master protocol instance Index attribute in order to link AO to it. <i>Attribute is optional and doesn't have to be included in configuration, value of the IEC101sl.Source or IEC104sl.Source attributes will be used if omitted.</i>
Index	-8...2 ³² - 1	Destination AO object. Any AO element node of the selected Master protocol instance can be used as a destination. Use value of the AO.Index attribute of any AO element node listed in the IO table of the selected Master protocol instance. <i>Indexes don't have to be arranged in an ascending order.</i>
InfAddr	1...16777215	Information Object Address (IOA) of the AO object. This IOA will be used to receive command from upstream Master station. <i>Addresses don't have to be arranged in an ascending order.</i>
qualifier	See table 5.14 for description	Internal object qualifier to enable customized data processing. See table 5.14 for internal object qualifier description. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Coeff	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Coefficient to multiply the setpoint object value before forwarding to linked protocol instance. (default value 1) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Policy	0...255	Command execution policy, see table 5.16 for description. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
TypeID	See table 5.15 for description	Only accept command if received with this ASDU Type. Value 0 disables incoming command ASDU type checking and any command is accepted. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Total	1...16777215	Total number of information objects. Attribute is used to create sequence of information objects with consecutive AO.Index and AO.InfAddr attribute values without a need to create individual AO nodes for each information object. (default value 1; only 1 object is created with this AO node) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Name	Max 100 chars	Freely configurable name, just for reference. <i>Name attribute is optional and doesn't have to be included in configuration.</i>

5.5.2 AO.qualifier

Table 5.14 IEC 60807-5-101/104 Slave AO internal qualifier

Bits	Values	Description
qualifier [xxxx.xxxx]	0...0xFF	AO internal qualifier has 8 data bits
Bits 6;5	x00x.xxxx	Only Direct-Execute commands are accepted
	x01x.xxxx	Direct-Execute and Select-before-Execute commands are accepted
	x10x.xxxx	Only Select-Before-Execute commands are accepted
	x11x.xxxx	Reserved for future use
Bit 7	0xxx.xxxx	AO is enabled and command will be processed when received
	1xxx.xxxx	AO is disabled and command will be rejected when received
Bits 0...4	Any	Bits reserved for future use

5.5.3 AO.TypeID

Table 5.15 IEC 60807-5-101/104 Slave AO TypeID

TypeID Value	Description
48	Only 'Normalized setpoint command' will be accepted and processed (ASDU type 48 [C_SE_NA_1])
49	Only 'Scaled setpoint command' will be accepted and processed (ASDU type 49 [C_SE_NB_1])
50	Only 'Short floating point setpoint command' will be accepted and processed (ASDU type 50 [C_SE_NC_1])
61	Only applicable to IEC60870-5-104 Slave protocol instance; Only time-tagged 'Normalized setpoint command' will be accepted and processed (ASDU type 61 [C_SE_TA_1])
62	Only applicable to IEC60870-5-104 Slave protocol instance; Only time-tagged 'Scaled setpoint command' will be accepted and processed (ASDU type 62 [C_SE_TB_1])
63	Only applicable to IEC60870-5-104 Slave protocol instance; Only time-tagged 'Short floating point setpoint command' will be accepted and processed (ASDU type 63 [C_SE_TC_1])
Other	Undefined, setpoint command received with any ASDU type will be accepted

5.6 DO/AO.Policy

Table 5.16 IEC 60807-5-101/104 Slave command execution policy

Policy Values	Description
0	Select and Execute commands received from upstream Master station will be forwarded to the destination outstation. Command responses to upstream Master station will be sent only after received from the destination outstation.
1	Select command confirmation response to upstream Master station will be generated by the communication protocol instance immediately after command reception. Execute command will be forwarded to the destination outstation and response to upstream Master station will be sent only after received from the destination outstation
2	Select and Execute command confirmation responses to upstream Master station will be generated by the communication protocol instance immediately after command reception. Termination response to upstream Master station will be sent only after received from the destination outstation
250	Dummy policy can be used to check availability of the destination outstation and DO/AO object configuration. All DO/AO command validation checks will be performed, but no actual command will be sent to the destination station. Positive confirmation and termination responses will be generated by the communication protocol instance if command validation was successfully and destination outstation is online
3...249	Reserved for future use

5.7 AUTOCfg group and AUTO node

Group node [AUTOCfg](#) and element nodes [AUTO](#) enable automatic object linking without individually defining each DI/AI/DO/AO object in the table. All DI/AI/DO/AO objects of the Master protocol instance can be automatically linked to Slave protocol instance without individual defining each object in Slave protocol instance's object table. Objects can be automatically linked simply by using Master protocol instance's Index in the Source attribute. By default DI/AI/DO/AO object information addresses will be the same as defined in Master protocol instance's object table. It is also possible to override automatic information address initialization and have them initialized sequentially using [DIInfAddr](#); [AIInfAddr](#); [DOInfAddr](#); [AOInfAddr](#) attributes. The first object will have information address as specified in corresponding [DIInfAddr](#); [AIInfAddr](#); [DOInfAddr](#); [AOInfAddr](#) attribute and remaining objects will be initialized sequentially. [AUTOCfg](#) group node can have multiple [AUTO](#) nodes as shown in the sample below.

```
<AutoCfg>
  <AUTO Source="1"   Name="RTU1" />
  <AUTO Source="2"   Name="RTU2" />
  <AUTO Name="RTU3" />
</AutoCfg>
```

Please see sample [AUTO](#) element node below listing all available attributes.

```
<AUTO Source="1"
  DIInfAddr="1001"
  AIInfAddr="2001"
  DOInfAddr="4001"
  AOInfAddr="5001"
  DIQual="0x00"
  AIQual="0x00"
  DOQual="0x00"
  AOQual="0x00"
  DIGroupMask="0x0001"
  AIGroupMask="0x0002"
  Policy="0"
  CommsOnlineAddr="1"
  Name="Auto configuration" />
```

Tip:

Attributes of the [AUTO](#) element node can be arranged in any order, it will not affect the XML file validation.

Table 5.17 IEC 60807-5-101/104 Slave AUTO attributes

Attribute	Values or range	Description
Source	1...255	Source communication protocol instance. Any Master protocol instance listed in CommunicationCfg group can be used as a source. Use value of the Master protocol instance Index attribute in order to link to it. Attribute is optional and doesn't have to be included in configuration, value of the IEC101sl.Source or IEC104sl.Source attributes will be used if omitted.
DIInfAddr	1...16777215	Base DI information object address, DI objects will be initialized sequentially starting with this information address. Attribute is optional and doesn't have to be included in configuration, DI objects will have the same information addresses as defined in source communication protocol object table.

Continued on next page

Table 5.17 – continued from previous page

Attribute	Values or range	Description
AIInfAddr	1...16777215	Base AI information object address, AI objects will be initialized sequentially starting with this information address. Attribute is optional and doesn't have to be included in configuration, AI objects will have the same information addresses as defined in source communication protocol object table.
DOInfAddr	1...16777215	Base DO information object address, DO objects will be initialized sequentially starting with this information address. Attribute is optional and doesn't have to be included in configuration, DO objects will have the same information addresses as defined in source communication protocol object table.
AOInfAddr	1...16777215	Base AO information object address, AO objects will be initialized sequentially starting with this information address. Attribute is optional and doesn't have to be included in configuration, AO objects will have the same information addresses as defined in source communication protocol object table.
DIqual	See table 5.2 for description	Internal DI object qualifier to enable customized data processing. See table 5.2 for internal object qualifier description. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
AIqual	See table 5.6 for description	Internal AI object qualifier to enable customized data processing. See table 5.6 for internal object qualifier description. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
DOqual	See table 5.10 for description	Internal DO object qualifier to enable customized data processing. See table 5.10 for internal object qualifier description. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
AOqual	See table 5.14 for description	Internal AO object qualifier to enable customized data processing. See table 5.14 for internal object qualifier description. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
DIGroupMask	0...0xFFFF	Include DI objects in Interrogation group/groups. Each bit of the group mask attribute needs to be set in order to include object in a particular interrogation group. Please refer to the table 5.8 for more information. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Continued on next page		

Table 5.17 – continued from previous page

Attribute	Values or range	Description
AIGroupMask	0...0xFFFF	Include AI objects in Interrogation group/groups. Each bit of the group mask attribute needs to be set in order to include object in a particular interrogation group. Please refer to the table 5.8 for more information. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Policy	0...255	Command execution policy, see table 5.16 for description. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
CommsOnlineAddr	1...16777215	Information address to report service DI – peer station communication (Online/Offline) status. Attribute is optional and doesn't have to be included in configuration, communication status will not be reported if omitted.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

IEC60870-5-101 Master configuration

This section describes how to configure IEC 60870-5-101 controlling station (Master) communication protocol instance. Each IEC 60870-5-101 controlling station (Master) communication protocol instance must have XML configuration file where its IO object table and additional protocol-related settings will be stored. One and the same XML configuration file can be used for multiple IEC 60870-5-101 controlling station (Master) communication protocol instances, this becomes useful in case if identical sets of IO objects are acquired from several outstations.

Name and location path of the XML configuration file are not predefined, they can be chosen freely. File name '**IEC101ma_test.xml**' will be used as a sample and location path doesn't need to be specified if XML file is stored in the same directory as leandc firmware. In order to use the XML file for a communication protocol instance, simply enter the name '**IEC101ma_test.xml**' in [IEC101ma.XMLpath](#) attribute.

IEC60870-5-101 Master configuration file (e.g. '**IEC101ma_test.xml**') must have a root object node [IEC101maConfig](#) which has 5 child group object nodes [VersionControl](#); [ProtocolCfg](#); [DITable](#); [AITable](#); [DOTable](#); [AOTable](#) please see the sample below.

```
<IEC101maConfig xmlns="http://www.londelec.com/xmlschemas/leandc/IEC101ma" ... version="1.00">
  <VersionControl conf="4" date="2014-01-18" time="10:08:09"/>
  <ProtocolCfg>
    <XMLSettings IOAOverlap="1" />
    <CommsSettings OfflineDelay="120" />
    ...
  </ProtocolCfg>
  <DITable>
    <DI Index="0" InfAddr="1" qualifier="0x10" Total="16"/>
    ...
  </DITable>
  <AITable>
    <AI Index="0" InfAddr="1" qualifier="0x00" Total="16" Coeff="1"/>
    ...
  </AITable>
  <DOTable>
    <DO Index="0" InfAddr="1"TypeID="46" Total="16"/>
    ...
  </DOTable>
  <AOTable>
    <AO Index="0" InfAddr="1"TypeID="50" Total="16"/>
    ...
  </AOTable>
</IEC101maConfig>
```

[DITable](#); [AITable](#); [DOTable](#); [AOTable](#) group nodes compose an IO object table and they are common for IEC60870-5-101 and IEC60870-5-104 controlling station (Master) communication protocol instances. Please refer to the tables [8.1](#); [8.4](#); [8.7](#) and [8.11](#) for their attributes.

6.1 ProtocolCfg group node

Protocol-related settings of the IEC60870-5-101 controlling station (Master) communication protocol instance are configured using various child element nodes under [ProtocolCfg](#) group node.

Important:

It is essential to keep element nodes in the listed order otherwise it will affect the XML file validation.

Please see sample [ProtocolCfg](#) group node and the table listing all available child element nodes below.

```
<ProtocolCfg>
  <XMLSettings ... />
  <LinkSettings ... />
  <CommsSettings ... />
  <ASDUSettings ... />
  <Timeouts ... />
  <TimeSettings ... />
  <Broadcast ... />
  <Periodic ... />
  <BufferSizes ... />
</ProtocolCfg>
```

Tip:

All element nodes are optional, default values will be used for attributes of omitted nodes.

Table 6.1 IEC 60807-5-101 Master ProtocolCfg child element nodes

Attribute	Values or range	Description
XMLSettings	See table 6.2	XML parse setting specification node. Refer to table 6.2 for attribute specification.
LinkSettings	See table 6.3	Communication link layer timeout and control bit configuration node. Refer to table 6.3 for attribute specification.
CommsSettings	See table 6.4	Communication status (e.g. online and offline) change behavior and related delay configuration node. Refer to table 6.4 for attribute specification.
ASDUSettings	See table 6.5	Various application layer settings configuration node. Refer to table 6.5 for attribute specification.
Timeouts	See table 6.6	Control command expiration timeout configuration node. Refer to table 6.6 for attribute specification.
TimeSettings	See table 6.7	Unique time settings (e.g. time zone) of particular protocol instance. Refer to table 6.7 for attribute specification.
Broadcast	See table 6.8	Broadcast or individual common address of ASDU (CAA) specification node. Refer to table 6.8 for attribute specification.
Periodic	See table 6.9	Periodically generated message configuration node. Refer to table 6.9 for attribute specification.
BufferSizes	See table 6.10	Various application layer buffer size configuration node. Refer to table 6.10 for attribute specification.

6.1.1 XMLSettings attributes

XML file parse settings such as information object address validation can be specified using attributes of [XMLSettings](#) element node.

Please see sample [XMLSettings](#) node and the table listing all available attributes below.

```
<XMLSettings IOAOverlap="1" />
```

Table 6.2 IEC 60807-5-101 Master XMLSettings attributes

Attribute	Values or range	Description
IOAOverlap	0	Each information object (DI/AI/DO/AO) specified in an IO table must have unique information object address (IOA). Error message will be generated and IO object table will be purged if address duplication is detected. (default value)
	1	Information address duplication is checked only within confines of a particular object type (DI/AI/DO/AO). Objects of different types are allowed to reuse same information addresses. Error message will be generated and objects of a particular type will be purged if address duplication is detected.

6.1.2 LinkSettings attributes

Link layer settings can be specified using attributes of [LinkSettings](#) element node.

Please see sample [LinkSettings](#) node and the table listing all available attributes below.

```
<LinkSettings LinkAddrSize="1" TxAllVarLength="0" LinkOnlineCounter="5"/>
```

Table 6.3 IEC 60807-5-101 Master LinkSettings attributes

Attribute	Values or range	Description
LinkAddrSize	1 or 2	Link layer address size in bytes (default 1 byte) Please note link address size of the protocol instances sharing the same hardware node must be the same.
TxAllVarLength	0	Send variable and fixed length link layer messages as required (default value) (Variable link layer messages start with 0x68 and fixed length messages start with 0x10)
	1	Send only variable length link layer messages
LinkOnlineCounter	0...255	Application layer operation delay after link becomes valid. First application layer message (e.g. GI or Time Sync) will be delayed for a configured number of outgoing messages after Reset Remote link response from outstation. Value 0 doesn't delay application layer operation, application layer starts running immediately after Reset Remote link response is received from outstation. (default 0 messages)

6.1.3 CommsSettings attributes

Communication state reporting and related delays can be specified using attributes of [CommsSettings](#) element node. Please see sample [CommsSettings](#) node and the table listing all available attributes below.

```
<CommsSettings NoRespCount="5"
  DegradedRetries="5"
  DegradedTimeout="600"
  ControlLockTimer="20"
  OfflineDelay="10"
  OnlineGIDelay="10"
  OfflineNTDelay="1000"
  DisabledNT="1" />
```

Table 6.4 IEC 60807-5-101 Master CommsSettings attributes

Attribute	Values or range	Description
NoRespCount	1...255	Outstation no-response counter. Station status will be changed to OFFLINE and Invalid [IV] bit of all DI/AI information objects will be set if outstation fails to reply to a configured number of subsequent requests. Outstation status will be changed to OFFLINE immediately unless additional OfflineDelay is specified. (default 5 retries; leandc will retry outgoing message for 5 times before changing outstation status to OFFLINE) (default 5 retries)
DegradedRetries	0...255	Outgoing message retries before activating DegradedTimeout . Outstation will be temporarily excluded from polling if it fails to reply to a configured number of requests. Value 0 disables degraded timeout functionality (default 5 retries)
DegradedTimeout	0...2 ³² - 1	Degraded timeout in seconds. Outstation is excluded from polling for a configured number of seconds if it has failed to reply to a number of requests configured in DegradedRetries node. Value 0 disables degraded timeout functionality (default 600 seconds)
ControlLockTimer	0...120	Control command lock timer is used to poll only one outstation for a configured number of seconds after sending a control command. All other outstations sharing the same hardware channel are temporary excluded from polling while ControlLockTimer operates. This feature allows to speed up reception of a control command feedback. ControlLockTimer can be used only if more than one outstation uses the same hardware channel. Value 0 disables control lock timer feature. (default 30 seconds)
OfflineDelay	0...2 ³² - 1	Offline delay in seconds before outstation status is changed to OFFLINE. Offline delay timer is activated only after outstation has failed to reply to a number of requests configured in NoRespCount node. (example, if this delay is 10, status will be changed to OFFLINE when outstation has failed to reply to a number of requests configured in NoRespCount plus 10 second delay (default 0 seconds)

Continued on next page

Table 6.4 – continued from previous page

Attribute	Values or range	Description
OnlineGIDelay	$0 \dots 2^{32} - 1$	General interrogation command will be delayed by a configured number of seconds when outstation becomes online. Delay is designed to allow outstation to acquire data after reset/power-on and before leandc issues General Interrogation (default value 0)
OfflineNTDelay	$0 \dots 2^{32} - 1$	DI/AI objects will be marked with Not Topical [NT] bit for a configured number of seconds when station goes offline. DI/AI objects will be marked with Invalid [IV] bit after this delay expires. Objects are never marked with Not Topical [NT] bit if this delay is 0. (default 0 seconds)
DisabledNT	0	Mark DI/AI objects with Invalid [IV] bit when communication disable service command is received (default value)
	1	Mark DI/AI objects with Not Topical [NT] bit when communication disable service command is received

6.1.4 ASDUSettings attributes

Application layer settings can be specified using attributes of [ASDUSettings](#) element node.

Please see sample [ASDUSettings](#) node and the table listing all available attributes below.

```
<ASDUSettings COTSize="1"
  CAASize="1"
  IOASize="2"
  InvalidEvent="1"
  IgnoreTimetags="1"
  SUthroughoutDST="1"
  AIDeadband="2"
  AIPercent="0.5"
  DOQOC="1"
  DOType="46"
  AOType="50"
  DIEventStartup="1"
  AIEventStartup="1" />
```

Table 6.5 IEC 60807-5-101 Master ASDUSettings attributes

Attribute	Values or range	Description
COTSize	1 or 2	Cause Of Transmission size in bytes including Originator address (default 1 byte, if originator address is not used)
CAASize	1 or 2	Common address of ASDU size in bytes (default 1 byte)
IOASize	1; 2 or 3	Information Object Address size in bytes (default 2 bytes)
InvalidEvent	0	Events with set Invalid [IV] bit will not be generated
	1	Events with set Invalid [IV] bit will be generated (default value)
IgnoreTimetags	0	Use original timetag when events are received from outstation (default value)
	1	Substitute timetag with the local time when events are received from outstation
SUthroughoutDST	0	Summer Time [SU] bit of any outgoing message timestamp will be set to indicate last hour of the summer time before clock adjustment at the end of DST (when clock is changed one hour back) (default value)
	1	Summer Time [SU] bit of any outgoing message timestamp will always be set if date and time of the timestamp is Summer time. <i>Please note this functionality is deviation from the communication standard and option should be avoided.</i>
AIDeadband	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Deadband for all AI objects which doesn't have AI.Deadband attribute specified in their element node. Refer to individual AI.Deadband attribute description for more information. Value 0 disables deadband feature. (default value 0)
AIPercent	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Percent deadband for all AI objects which doesn't have AI.Percent attribute specified in their element node. Refer to individual AI.Percent attribute description for more information. Value 0 disables percent feature. (default value 0)

Continued on next page

Table 6.5 – continued from previous page

Attribute	Values or range	Description
DOQOC	See table 8.10 for description	Qualifier Of Command (QOC) is used to set additional information (e.g. [no additional definition]; [short-pulse duration]) when command is being sent to the DO object which doesn't have DO.QOC attribute specified in its element node. Refer to table 8.10 for QOC values. (default value 0 [no additional definition])
DOType	See table 8.9 for description	DO ASDU type is used when command is being sent to the DO object which doesn't have DO.TypeID attribute specified in its element node. Refer to table 8.9 for TypeID values. (there is no default value, ASDU TypeID is transparent if neither this element nor DO.TypeID attribute is used)
AOType	See table 8.13 for description	AO ASDU type is used when command is being sent to the AO object which doesn't have AO.TypeID attribute specified in its element node. Refer to table 8.13 for TypeID values. (there is no default value, ASDU TypeID is transparent if neither this element nor AO.TypeID attribute is used)
DIEventStartup	0	DI events will not be generated when received from outstation for the first time after system startup
	1	DI events will be generated when received from outstation for the first time after system startup (default value)
AIEventStartup	0	AI events will not be generated when received from outstation for the first time after system startup
	1	AI events will be generated when received from outstation for the first time after system startup (default value)

6.1.5 Timeouts attributes

Timeout values can be specified using attributes of [Timeouts](#) element node.

Please see sample [Timeouts](#) node and the table listing all available attributes below.

```
<Timeouts Application="30" Command="10" Select="30" />
```

Table 6.6 IEC 60807-5-101 Master Timeouts attributes

Attribute	Values or range	Description
Application	$1 \dots 2^{32} - 1$	Application timeout is a delay in seconds for how long communication protocol instance waits response from downstream outstation after control command has been sent. If no response is received within a configured timeout, command is considered to be failed and processing is terminated (command gets removed from the buffer). In general application timeout is used to terminate pending control commands, if communication to downstream outstation is lost. (default 30 seconds)
Command	$1 \dots 2^{32} - 1$	Command timeout is a delay in seconds for how long communication protocol instance tries to send command response to upstream Master station. If it is impossible to send the response within a configured timeout, command is considered to be failed and processing is terminated (command gets removed from the buffer). In general command timeout is used to terminate pending control commands, if communication to upstream Master station is lost. (default 10 seconds)
Select	$1 \dots 2^{32} - 1$	Select timeout is a maximal delay in seconds between received Select and Execute commands. If an Execute command is not received within a configured timeout, command is automatically de-selected, Execute command will not be accepted and new Select command is required. In general Select timeout is used to test reliability of the communication channel before executing control commands to prevent major delays due to intermittent communications (default 30 seconds)

6.1.6 TimeSettings attributes

Time settings of each communication protocol instance can be specified using attributes of [TimeSettings](#) element node.

Please see sample [TimeSettings](#) node and the table listing all available attributes below.

```
<TimeSettings TimeZone="Europe/Riga" />
```

Table 6.7 IEC 60807-5-101/104 Master TimeSettings attributes

Attribute	Values or range	Description
TimeZone	Max 200 chars	Adjust incoming and outgoing message timestamps assuming peer station operates within the specified time zone. TimeZone attribute must not be used if not required, there is no default value. Message timestamps will not be adjusted if attribute omitted. Please see Time Zone specification for additional information.

6.1.7 Broadcast attributes

Broadcast common address of ASDU (CAA) usage for various commands can be specified using attributes of [Broadcast](#) element node.

Please see sample [Broadcast](#) node and the table listing all available attributes below.

```
<Broadcast GI="1" TimeSync="0" />
```

Table 6.8 IEC 60807-5-101 Master Broadcast attributes

Attribute	Values or range	Description
GI	0	Send General interrogation commands with individual common addresses of ASDU (CAA) (default value 0)
	1	Send General interrogation commands with broadcast common address of ASDU (CAA). Broadcast addresses are 255 (if size of the CAA is 1 byte) and 65535 (if size of the CAA is 2 bytes)
TimeSync	0	Send Time Synchronization commands with individual link and common addresses of ASDU (CAA) (default value 0)
	1	Send Time Synchronization commands with broadcast link and common address of ASDU (CAA). Broadcast addresses are 255 (if size of corresponding address is 1 byte) and 65535 (if size of corresponding address is 2 bytes)

6.1.8 Periodic attributes

Periodic intervals of sending various messages can be specified using attributes of [Periodic](#) element node. Please see sample [Periodic](#) node and the table listing all available attributes below.

```
<Periodic GI="600" Group1="300" Group16="400" />
```

Table 6.9 IEC 60807-5-101 Master Periodic attributes

Attribute	Values or range	Description
GI	$0 \dots 2^{32} - 1$	Periodic General Interrogation command interval in seconds. Value 0 disables periodic General Interrogation command. (default value 0)
Group1	$0 \dots 2^{32} - 1$	Periodic Group 1 Interrogation command interval in seconds. Value 0 disables periodic Group 1 Interrogation command. (default value 0)
Group2 ... Group15	$0 \dots 2^{32} - 1$	Periodic Group 2...15 Interrogation command interval in seconds. Value 0 disables periodic Group 2...15 Interrogation command. ..tip:: Please note, Interrogation Groups 2...15 are configured individually, each group has its own element node (default value 0)
Group16	$0 \dots 2^{32} - 1$	Periodic Group 16 Interrogation command interval in seconds. Value 0 disables periodic Group 16 Interrogation command. (default value 0)
TimeSync	$0 \dots 2^{32} - 1$	Periodic Time synchronization command interval in seconds. Value 0 disables time synchronization command. (default value 0)

6.1.9 BufferSizes attributes

Various communication buffer sizes and can be specified using attributes of [BufferSizes](#) element node.

Please see sample [BufferSizes](#) node and the table listing all available attributes below.

```
<BufferSizes DO="1" />
```

Table 6.10 IEC 60807-5-101 Master BufferSizes attributes

Attribute	Values or range	Description
DO	1...255	Control command buffer size in entries. Communication protocol instances use designated buffer to hold received control commands until command execution is completed. It is possible to create a queue, where commands are executed sequentially one after another. Set DO greater than 1 in order to enable this feature. (default value 1; only one control command will be processed at a time. New command received before previous command execution is complete will be rejected)

IEC60870-5-104 Master configuration

This section describes how to configure IEC 60870-5-104 controlling station (Master) communication protocol instance. Each IEC 60870-5-104 controlling station (Master) communication protocol instance must have XML configuration file where its IO object table and additional protocol-related settings will be stored. One and the same XML configuration file can be used for multiple IEC 60870-5-104 controlling station (Master) communication protocol instances, this becomes useful in case if identical sets of IO objects are acquired from several outstations.

Name and location path of the XML configuration file are not predefined, they can be chosen freely. File name 'IEC104ma_test.xml' will be used as a sample and location path doesn't need to be specified if XML file is stored in the same directory as leandc firmware. In order to use the XML file for a communication protocol instance, simply enter the name 'IEC104ma_test.xml' in [IEC104ma.XMLpath](#) attribute.

IEC60870-5-104 Master configuration file (e.g. 'IEC104ma_test.xml') must have a root object node [IEC104maConfig](#) which has 6 child group object nodes [VersionControl](#); [ProtocolCfg](#); [DITable](#); [AITable](#); [DOTable](#); [AOTable](#) please see the sample below.

```
<IEC104maConfig xmlns="http://www.londelec.com/xmlschemas/leandc/IEC104ma" ... version="1.00">
  <VersionControl conf="4" date="2014-01-18" time="10:08:09"/>
  <ProtocolCfg>
    <XMLSettings IOAOverlap="1" />
    <CommsSettings OfflineDelay="120" />
    ...
  </ProtocolCfg>
  <DITable>
    <DI Index="0" InfAddr="1" qualifier="0x10" Total="16"/>
    ...
  </DITable>
  <AITable>
    <AI Index="0" InfAddr="1" qualifier="0x00" Total="16" Coeff="1"/>
    ...
  </AITable>
  <DOTable>
    <DO Index="0" InfAddr="1"TypeID="46" Total="16"/>
    ...
  </DOTable>
  <AOTable>
    <AO Index="0" InfAddr="1"TypeID="50" Total="16"/>
    ...
  </AOTable>
</IEC104maConfig>
```

[DITable](#); [AITable](#); [DOTable](#); [AOTable](#) group nodes compose an IO object table and they are common for IEC60870-5-101 and IEC60870-5-104 controlling station (Master) communication protocol instances. Please refer to the tables [8.1](#); [8.4](#); [8.7](#) and [8.11](#) for their attributes.

7.1 ProtocolCfg group node

Protocol-related settings of the IEC60870-5-104 controlling station (Master) communication protocol instance are configured using various child element nodes under [ProtocolCfg](#) group node.

Important:

It is essential to keep element nodes in the listed order otherwise it will affect the XML file validation.

Please see sample [ProtocolCfg](#) group node and the table listing all available child element nodes below.

```
<ProtocolCfg>
  <XMLSettings ... />
  <TransportSettings ... />
  <CommsSettings ... />
  <ASDUSettings ... />
  <Timeouts ... />
  <TimeSettings ... />
  <Broadcast ... />
  <Periodic ... />
  <BufferSizes ... />
</ProtocolCfg>
```

Tip:

All element nodes are optional, default values will be used for attributes of omitted nodes.

Table 7.1 IEC 60807-5-104 Master ProtocolCfg element nodes

Attribute	Values or range	Description
XMLSettings	See table 7.2	XML parse setting specification node. Refer to table 7.2 for attribute specification.
TransportSettings	See table 7.3	Communication transport interface timeout and message window size configuration node. Refer to table 7.3 for attribute specification.
CommsSettings	See table 7.4	Communication status (e.g. online and offline) change behavior and related delay configuration node. Refer to table 7.4 for attribute specification.
ASDUSettings	See table 7.5	Various application layer settings configuration node. Refer to table 7.5 for attribute specification.
Timeouts	See table 7.6	Control command expiration timeout configuration node. Refer to table 7.6 for attribute specification.
TimeSettings	See table 7.7	Unique time settings (e.g. time zone) of particular protocol instance. Refer to table 7.7 for attribute specification.
Broadcast	See table 7.8	Broadcast or individual common address of ASDU (CAA) specification node. Refer to table 7.8 for attribute specification.
Periodic	See table 7.9	Periodically generated message configuration node. Refer to table 7.9 for attribute specification.
BufferSizes	See table 7.10	Various application layer buffer size configuration node. Refer to table 7.10 for attribute specification.

7.1.1 XMLSettings attributes

XML file parse settings such as information object address validation can be specified using attributes of [XMLSettings](#) element node.

Please see sample [XMLSettings](#) node and the table listing all available attributes below.

```
<XMLSettings IOAOverlap="1" />
```

Table 7.2 IEC 60807-5-104 Master XMLSettings attributes

Attribute	Values or range	Description
IOAOverlap	0	Each information object (DI/AI/DO/AO) specified in an IO table must have unique information object address (IOA). Error message will be generated and IO object table will be purged if address duplication is detected. (default value)
	1	Information address duplication is checked only within confines of a particular object type (DI/AI/DO/AO). Objects of different types are allowed to reuse same information addresses. Error message will be generated and objects of a particular type will be purged if address duplication is detected.

7.1.2 TransportSettings attributes

Protocol transport interface settings can be specified using attributes of [TransportSettings](#) element node.

Please see sample [TransportSettings](#) node and the table listing all available attributes below.

```
<TransportSettings T0="30" T1="15" T2="10" T3="20" Kparam="12" Wparam="8" />
```

Table 7.3 IEC 60807-5-104 Master TransportSettings attributes

Attribute	Values or range	Description
T0	1...65535	Timeout of connection establishment as per IEC 60870-5-104 standard. It is a delay in seconds for how long TCP socket should wait acknowledge from a peer station after sending connection establishment request (e.g. TCP SYN) (default 30 seconds)
T1	1...65535	Timeout of send or test APDUs as per IEC 60870-5-104 standard. It is a delay in seconds for how long communication protocol instance waits a reply to a sent APDU [I-frame] or test message [TESTFR_act]. If no reply is received from peer station within a configured timeout, communication protocol instance initiates active close of the TCP socket (default 15 seconds)
T2	1...65535	Timeout for acknowledges in case of no data messages as per IEC 60870-5-104 standard. (requirement: T2timer < T1timer) It is a delay in seconds before communication protocol instance sends an acknowledge [S-frame] in case there are any unacknowledged messages from the peer station. (default 10 seconds)
T3	1...65535	Timeout for sending test messages in case of a long idle state from IEC 60870-5-104 standard. It is a maximal idle time in seconds before a test message [TESTFR_act] is sent to a peer station by the communication protocol instance. If this timeout is selected greater than T3 timeout configured in the peer station, it is most likely the test message will be sent by the peer station first (default 20 seconds)
Kparam	1...30	Maximum difference receive sequence number to send state variable as per IEC 60870-5-104 standard. Maximal number of outgoing APDU messages [I-frames] communication protocol instance will send to a peer station before it waits for an acknowledge [S-frame] (default 12 APDU messages)
Wparam	1...29	Latest acknowledge after receiving w number I format APDUs as per IEC 60870-5-104 standard. Number of incoming APDU messages [I-frames] received from a peer station before communication protocol instance sends an acknowledge [S-frame] (default 8 APDU messages)

7.1.3 CommsSettings attributes

Communication state change behavior and related delays can be specified using attributes of [CommsSettings](#) element node.

Please see sample [CommsSettings](#) node and the table listing all available attributes below.

```
<CommsSettings OfflineDelay="10"
  OnlineGIDelay="10"
  GIAfterRecovery="1"
  OfflineNTDelay="1000"
  DisabledNT="1" />
```

Table 7.4 IEC 60807-5-104 Master CommsSettings attributes

Attribute	Values or range	Description
OfflineDelay	0...2 ³² - 1	Offline delay in seconds before outstation status is changed to OFFLINE. Offline delay timer is activated after TCP socket has been closed. Default 6 seconds - station status will be changed to OFFLINE 6 seconds after TCP socket has been closed by either peer (default 6 seconds)
OnlineGIDelay	0...2 ³² - 1	General interrogation command will be delayed by a configured number of seconds when outstation becomes online. Delay is designed to allow outstation to acquire data before it is being requested by General Interrogation (default value 0)
GIAfterRecovery	0	Don't send General Interrogation command when outstation becomes online after a communication loss. (Outstation status changes to ONLINE). <i>General Interrogation is always sent on leandc startup regardless the setting of this node.</i>
	1	Send General Interrogation command when outstation becomes online after a communication loss. (Outstation status changes to ONLINE) (default value)
OfflineNTDelay	0...2 ³² - 1	DI/AI objects will get marked with Not Topical [NT] bit for a configured number of seconds when station goes offline. After the delay DI/AI objects will be marked with Invalid [IV] bit. Objects are not marked with Not Topical [NT] bit if this delay is 0. (default 0 seconds)
DisabledNT	0	Mark DI/AI objects with Invalid [IV] bit when communication disable service command is received (default value)
	1	Mark DI/AI objects with Not Topical [NT] bit when communication disable service command is received

7.1.4 ASDUSettings attributes

Application layer settings can be specified using attributes of [ASDUSettings](#) element node.

Please see sample [ASDUSettings](#) node and the table listing all available attributes below.

```
<ASDUSettings InvalidEvent="1"
IgnoreTimetags="1"
SUthroughoutDST="1"
AIDeadband="2"
AIPercent="0.5"
DOQOC="1"
DOType="46"
AOType="50"
DIEventStartup="1"
AIEventStartup="1" />
```

Table 7.5 IEC 60807-5-104 Master ASDUSettings attributes

Attribute	Values or range	Description
InvalidEvent	0	Events with set Invalid [IV] bit will not be generated
	1	Events with set Invalid [IV] bit will be generated (default value)
IgnoreTimetags	0	Use original timetag when events are received from outstation (default value)
	1	Substitute timetag with the local time when events are received from outstation
SUthroughoutDST	0	Summer Time [SU] bit of any outgoing message timestamp will be set to indicate last hour of the summer time before clock adjustment at the end of DST (when clock is changed one hour back) (default value)
	1	Summer Time [SU] bit of any outgoing message timestamp will always be set if date and time of the timestamp is Summer time. <i>Please note this functionality is deviation from the communication standard and option should be avoided.</i>
AIDeadband	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Deadband for all AI objects which doesn't have AI.Deadband attribute specified in their element node. Refer to individual AI.Deadband attribute description for more information. Value 0 disables deadband feature. (default value 0)
AIPercent	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Percent deadband for all AI objects which doesn't have AI.Percent attribute specified in their element node. Refer to individual AI.Percent attribute description for more information. Value 0 disables percent feature. (default value 0)
DOQOC	See table 8.10 for description	Qualifier Of Command (QOC) is used to set additional information (e.g. [no additional definition]; [short-pulse duration]) when command is being sent to the DO object which doesn't have DO.QOC attribute specified in its element node. Refer to table 8.10 for QOC values. (default value 0 [no additional definition])

Continued on next page

Table 7.5 – continued from previous page

Attribute	Values or range	Description
DOType	See table 8.9 for description	DO ASDU type is used when command is being sent to the DO object which doesn't have DO.TypeID attribute specified in its element node. Refer to table 8.9 for TypeID values. (there is no default value, ASDU TypeID is transparent if neither this element nor DO.TypeID attribute is used)
AOType	See table 8.13 for description	AO ASDU type is used when command is being sent to the AO object which doesn't have AO.TypeID attribute specified in its element node. Refer to table 8.13 for TypeID values. (there is no default value, ASDU TypeID is transparent if neither this element nor AO.TypeID attribute is used)
DIEventStartup	0	DI events will not be generated when received from outstation for the first time after system startup
	1	DI events will be generated when received from outstation for the first time after system startup (default value)
AIEventStartup	0	AI events will not be generated when received from outstation for the first time after system startup
	1	AI events will be generated when received from outstation for the first time after system startup (default value)

7.1.5 Timeouts attributes

Timeout values can be specified using attributes of [Timeouts](#) element node.

Please see sample [Timeouts](#) node and the table listing all available attributes below.

```
<Timeouts Application="30" Command="10" Select="30" />
```

Table 7.6 IEC 60807-5-104 Master Timeouts attributes

Attribute	Values or range	Description
Application	$1 \dots 2^{32} - 1$	Application timeout is a delay in seconds for how long communication protocol instance waits response from downstream outstation after control command has been sent. If no response is received within a configured timeout, command is considered to be failed and processing is terminated (command gets removed from the buffer). In general application timeout is used to terminate pending control commands, if communication to downstream outstation is lost. (default 30 seconds)
Command	$1 \dots 2^{32} - 1$	Command timeout is a delay in seconds for how long communication protocol instance tries to send command response to upstream Master station. If it is impossible to send the response within a configured timeout, command is considered to be failed and processing is terminated (command gets removed from the buffer). In general command timeout is used to terminate pending control commands, if communication to upstream Master station is lost. (default 10 seconds)
Select	$1 \dots 2^{32} - 1$	Select timeout is a maximal delay in seconds between received Select and Execute commands. If an Execute command is not received within a configured timeout, command is automatically de-selected, Execute command will not be accepted and new Select command is required. In general Select timeout is used to test reliability of the communication channel before executing control commands to prevent major delays due to intermittent communications (default 30 seconds)

7.1.6 TimeSettings attributes

Time settings of each communication protocol instance can be specified using attributes of [TimeSettings](#) element node.

Please see sample [TimeSettings](#) node and the table listing all available attributes below.

```
<TimeSettings TimeZone="Europe/Riga" />
```

Table 7.7 IEC 60807-5-101/104 Master TimeSettings attributes

Attribute	Values or range	Description
TimeZone	Max 200 chars	Adjust incoming and outgoing message timestamps assuming peer station operates within the specified time zone. TimeZone attribute must not be used if not required, there is no default value. Message timestamps will not be adjusted if attribute omitted. Please see Time Zone specification for additional information.

7.1.7 Broadcast attributes

Broadcast common address of ASDU (CAA) usage for various commands can be specified using attributes of [Broadcast](#) element node.

Please see sample [Broadcast](#) node and the table listing all available attributes below.

```
<Broadcast GI="1" />
```

Table 7.8 IEC 60807-5-104 Master Broadcast attributes

Attribute	Values or range	Description
GI	0	Send General interrogation commands with individual common addresses of ASDU (CAA) (default value 0)
	1	Send General interrogation commands with broadcast common address of ASDU (CAA). Broadcast address is 65535

7.1.8 Periodic attributes

Periodic intervals of sending various messages can be specified using attributes of [Periodic](#) element node. Please see sample [Periodic](#) node and the table listing all available attributes below.

```
<Periodic GI="600" Group1="300" Group16="400" />
```

Table 7.9 IEC 60807-5-104 Master Periodic attributes

Attribute	Values or range	Description
GI	$0 \dots 2^{32} - 1$	Periodic General Interrogation command interval in seconds. Value 0 disables periodic General Interrogation command. (default value 0)
Group1	$0 \dots 2^{32} - 1$	Periodic Group 1 Interrogation command interval in seconds. Value 0 disables periodic Group 1 Interrogation command. (default value 0)
Group2 ... Group15	$0 \dots 2^{32} - 1$	Periodic Group 2...15 Interrogation command interval in seconds. Value 0 disables periodic Group 2...15 Interrogation command. ..tip:: Please note, Interrogation Groups 2...15 are configured individually, each group has its own element node (default value 0)
Group16	$0 \dots 2^{32} - 1$	Periodic Group 16 Interrogation command interval in seconds. Value 0 disables periodic Group 16 Interrogation command. (default value 0)

7.1.9 BufferSizes attributes

Various communication buffer sizes and can be specified using attributes of [BufferSizes](#) element node.

Please see sample [BufferSizes](#) node and the table listing all available attributes below.

```
<BufferSizes DO="1" />
```

Table 7.10 IEC 60807-5-104 Master BufferSizes attributes

Attribute	Values or range	Description
DO	1...255	Control command buffer size in entries. Communication protocol instances use designated buffer to hold received control commands until command execution is completed. It is possible to create a queue, where commands are executed sequentially one after another. Set DO greater than 1 in order to enable this feature. (default value 1; only one control command will be processed at a time. New command received before previous command execution is complete will be rejected)

IEC60870-5-101/104 Master IO object table

This section describes how to configure IO object table for IEC 60870-5-101 and IEC 60870-5-104 controlling station (Master) communication protocol instance. Group object nodes [DITable](#); [AITable](#); [DOTable](#); [AOTable](#) are included in XML configuration files of the IEC60870-5-101 and IEC60870-5-104 controlling station (Master) communication protocol instances as described in previous sections **IEC60870-5-101 Master configuration** and **IEC60870-5-104 Master configuration**.

8.1 DI Table group and DI node

Group node [DI Table](#) and child element nodes [DI](#) are used to create DI information objects to receive status information from the downstream outstation. Each created DI information object can be used as source of information for any DI information object defined in IO table of the Slave protocol instances. If used as a source, status information received from an outstation will be forwarded to DI information object of the Slave protocol instance and then to the upstream Master station. Please refer to the section [DI Table group and DI node](#) for more information on how to use DI information object as a source.

In order to receive status information from downstream outstation information object address (IOA) needs to be entered in [DI.InfAddr](#) attribute. Status information is processed when received with any of the following ASDU types: 1 [M_SP_NA_1]; 2 [M_SP_TA_1]; 3 [M_DP_NA_1]; 4 [M_DP_TA_1]; 30 [M_SP_TB_1]; 31 [M_DP_TB_1]

Please see sample [DI Table](#) group node and [DI](#) child element nodes below. There are 5 DI information objects configured using 4 [DI](#) element nodes.

```
<DI Table>
  <DI Index="0" InfAddr="1" qualifier="0x00" />
  <DI Index="1" InfAddr="2" qualifier="0x10" />
  <DI Index="2" InfAddr="3" qualifier="0x10" TypeID="31"/>
  <DI Index="3" InfAddr="4" qualifier="0x00" Total="2"/>
</DI Table>
```

Please see sample [DI](#) element node below listing all available attributes.

```
<DI Index="0"
  InfAddr="1"
  qualifier="0"
  TypeID="31"
  Total="2"
  Name="CB position" />
```

Tip:

Attributes of the [DI](#) element node can be arranged in any order, it will not affect the XML file validation.

8.1.1 DI attributes

Table 8.1 IEC 60807-5-101/104 Master DI attributes

Attribute	Values or range	Description
Index	0...2 ³² - 8	Index is a unique identifier of the DI object. Index numbering must start with 0 and indexes must be arranged in an ascending order as it prevents insertion of a new object. This requirement is essential because it affects object mapping to Slave communication protocol instances.
InfAddr	1...16777215	Information Object Address (IOA) of the DI object. This IOA will be used to receive object from downstream outstation. Addresses don't have to be arranged in an ascending order.
qualifier	See table 8.2 for description	Internal object qualifier to enable customized data processing. See table 8.2 for internal object qualifier description. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
TypeID	See table 8.3 for description	Use this ASDU type to send a DI object upstream, if transparent ASDU function is enabled in Slave protocol instance using <i>ASDUSettings.TranspTypes</i> attribute. This ASDU type will be used to report object regardless of the received ASDU type. (There is no default value, attribute must not be specified if not used). Attribute is optional and doesn't have to be included in configuration.
Total	1...16777215	Total number of information objects. Attribute is used to create sequence of information objects with consecutive <i>DI.Index</i> and <i>DI.InfAddr</i> attribute values without a need to create individual <i>DI</i> nodes for each information object. (default value 1; only 1 object is created with this <i>DI</i> node) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

8.1.2 DI.qualifier

Table 8.2 IEC 60807-5-101/104 Master DI internal qualifier

Bits	Values	Description
qualifier [xxxx.xxxx]	0...0xFF	DI internal qualifier has 8 data bits
Bit 0	xxxx.xxx0	DI object will not be inverted (ON = 1; OFF = 0 for [M_SP_NA_1] type and ON = 2; OFF = 1; INTER = 0; INVALID = 3 for [M_DP_NA_1] type)
	xxxx.xxx1	DI object will be inverted (ON = 0; OFF = 1 for [M_SP_NA_1] type and ON = 1; OFF = 2; INTER = 0; INVALID = 3 for [M_DP_NA_1] type)
Bit 1	xxxx.xx0x	Additional 'Zero' DI event generation disabled
	xxxx.xx1x	Additional 'Zero' DI event generation enabled . An OFF event will be internally generated following every sent DI ON event. Static DI object will be set to OFF value, static value is used when Slave protocol instance responds to an Interrogation.
Bit 2	xxxx.x0xx	DI event is generated only when object state is changed
	xxxx.x1xx	DI event is generated every time it is received from outstation. Invalid [IV] flag is automatically cleared from these DI objects when outstation becomes online ensuring they are always valid. <i>This option is only used for backward compatibility.</i>
Bit 3	xxxx.0xxx	Use original timetag when event is received from outstation
	xxxx.1xxx	Substitute timetag with local time when event is received from outstation
Bit 7	0xxx.xxxx	DI is enabled and will be processed when received
	1xxx.xxxx	DI is disabled and will be discarded when received
Bits 4;6	Any	Bits reserved for future use

8.1.3 DI.TypeID

Table 8.3 IEC 60870-5-101/104 Slave DI TypeID

TypeID Value for IEC60870-5-101	TypeID Value for IEC60870-5-104	Description
1	1	Static DI 'Single-point Information' will be sent using ASDU type 1 [M_SP_NA_1] DI event will be sent using ASDU type 1 [M_SP_NA_1], no time-tag
2	N/A	Static DI 'Single-point Information' will be sent using ASDU type 1 [M_SP_NA_1] DI event will be sent using ASDU type 2 [M_SP_TA_1], CP24time2A , msec and min
3	3	Static DI 'Double-point Information' will be sent using ASDU type 3 [M_DP_NA_1] DI event will be sent using ASDU type 3 [M_DP_NA_1], no time-tag
4	N/A	Static DI 'Double-point Information' will be sent using ASDU type 3 [M_DP_NA_1] DI event will be sent using ASDU type 4 [M_DP_TA_1], CP24time2A , msec and min
30	30	Static DI 'Single-point Information' will be sent using ASDU type 1 [M_SP_NA_1] DI event will be sent using ASDU type 30 [M_SP_TB_1], CP56time2A , full time
31	31	Static DI 'Double-point Information' will be sent using ASDU type 3 [M_DP_NA_1] DI event will be sent using ASDU type 31 [M_DP_TB_1], CP56time2A , full time
Other	Other	Undefined, default values will be used: IEC 60870-5-101 default ASDU type 2 [M_SP_TA_1], CP24time2A , msec and min IEC 60870-5-104 default ASDU type 30 [M_SP_TB_1], CP56time2A , full time

Tip:

Note, all DI objects are internally stored and processed as 'Double-point status information'. If 'Single-point status information' type needs to be reported to the upstream Master station, object is being converted just before it is sent.

8.2 AITable group and AI node

Group node [AITable](#) and child element nodes [AI](#) are used to create AI information objects to receive analog information from the downstream outstation. Each created AI information object can be used as source of information for any AI information object defined in IO table of the Slave protocol instances. If used as a source, analog information received from an outstation will be forwarded to AI information object of the Slave protocol instance and then to the upstream Master station. Please refer to the section [AITable group and AI node](#) for more information on how to use AI information object as a source.

In order to receive analog information from the downstream outstation information object address (IOA) needs to be entered in [AI.InfAddr](#) attribute. Analog information is processed when received with any of the following ASDU types: 5 [M_ST_NA_1]; 6 [M_ST_TA_1]; 32 [M_ST_TB_1]; 9 [M_ME_NA_1]; 10 [M_ME_TA_1]; 34 [M_ME_TD_1]; 11 [M_ME_NB_1]; 12 [M_ME_TB_1]; 35 [M_ME_TE_1]; 13 [M_ME_NC_1]; 14 [M_ME_TC_1]; 36 [M_ME_TF_1]

Please see sample [AITable](#) group node and [AI](#) child element nodes below. There are 5 AI information objects configured using 4 [AI](#) element nodes.

```
<AITable>
  <AI Index="0" InfAddr="1" qualifier="0x20" Coeff="1.0" Deadband="0.5" Percent="0"/>
  <AI Index="1" InfAddr="2" qualifier="0x00" Coeff="1.0" Deadband="0" Percent="1.4"/>
  <AI Index="2" InfAddr="3" qualifier="0x00" Coeff="-17.0" Deadband="0" Percent="1.4" TypeID="36"/>
  <AI Index="3" InfAddr="4" qualifier="0x00" Coeff="0.08" Deadband="8" Percent="3" Total="2"/>
</AITable>
```

Please see sample [AI](#) element node below listing all available attributes.

```
<AI Index="0"
  InfAddr="1"
  qualifier="0x20"
  Coeff="1.0"
  Deadband="0.5"
  Percent="0"
  StartOffset="6554"
  ZeroDeadband="3.0"
  Offset="-2.0"
  OffsetDeadband="2.0"
  NonZeroOffset="200.0"
  TypeID="36"
  Total="2"
  Name="Feeder current" />
```

Tip:

Attributes of the [AI](#) element node can be arranged in any order, it will not affect the XML file validation.

8.2.1 AI attributes

Table 8.4 IEC 60807-5-101/104 Master AI attributes

Attribute	Values or range	Description
Index	$0 \dots 2^{32} - 8$	Index is a unique identifier of the AI object. Index numbering must start with 0 and indexes must be arranged in an ascending order as it prevents insertion of a new object. This requirement is essential because it affects object mapping to Slave communication protocol instances.
InfAddr	1...16777215	Information Object Address (IOA) of the AI object. This IOA will be used to receive object from downstream outstation. Addresses don't have to be arranged in an ascending order.
qualifier	See table 8.5 for description	Internal object qualifier to enable customized data processing. See table 8.5 for internal object qualifier description. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Coeff	$\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Coefficient to multiply the value of incoming analog object. (default value 1) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Deadband*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Absolute (static) deadband for a real-time analog value. AI value will be updated and an event will be generated if last received analog value exceeds the value stored in the leandc database plus/minus defined Deadband . Defined Deadband is added and subtracted from the analog value stored in the database in order to create absolute deadband range (range is: 'oldvalue - deadband' ... 'oldvalue + deadband'). New incoming analog value is checked against limits of this deadband and an event is generated if value is outside. Value 0 disables deadband feature. (default value 0) Attribute is optional and doesn't have to be included in configuration if not used.
Percent*	$\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Percent (dynamic) deadband for a real-time analog value. AI value will be updated and an event will be generated if last received analog value exceeds the value stored in the leandc database plus/minus defined Percent . Defined Percent is used to calculate absolute deadband based on the last analog value stored in the database. When absolute deadband range is calculated, the same procedure as described above applies. Value 0 disables percent deadband feature. (default value 0) Attribute is optional and doesn't have to be included in configuration if not used.
StartOffset*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Start offset normally used to compensate e.g. 4-20mA transducer output range, offset of 4mA. AI will be forced to 0 and IV bit set if a real-time value is below this threshold, otherwise this offset will be subtracted from a real-time value (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.

Continued on next page

Table 8.4 – continued from previous page

Attribute	Values or range	Description
ZeroDeadband *	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Zero Deadband is used to filter noise by forcing low AI values to 0. AI will be forced to 0 if its real-time absolute value (+/-) falls below ZeroDeadband attribute. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Offset *	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Offset AI value after ZeroDeadband has been applied. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
OffsetDeadband *	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Offset Zero Deadband is used to filter noise around 0 value after applying Offset . AI will be forced to 0 if its absolute value (+/-) after offsetting falls below OffsetDeadband attribute. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
NonZeroOffset *	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Offset only non-zero values after ZeroDeadband ; Offset and OffsetDeadband has been applied. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
TypeID	See table 8.6 for description	Use this ASDU type to send a AI object upstream, if transparent ASDU function is enabled in Slave protocol instance using ASDUSettings.TranspTypes attribute. This ASDU type will be used to report object regardless of the received ASDU type. (There is no default value, attribute must not be specified if not used). <i>Attribute is optional and doesn't have to be included in configuration.</i>
Total	1...16777215	Total number of information objects. Attribute is used to create sequence of information objects with consecutive AI.Index and AI.InfAddr attribute values without a need to create individual AI nodes for each information object. (default value 1; only 1 object is created with this AI node) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Name	Max 100 chars	Freely configurable name, just for reference. <i>Name attribute is optional and doesn't have to be included in configuration.</i>

Tip:

* Please refer to annex **Received AI processing** for additional information on AI processing options and application examples using [AI.Deadband](#); [AI.Percent](#) attributes. Annexes **AI scaling without StartOffset enabled** and **AI scaling with StartOffset enabled** for additional information on AI scaling.

8.2.2 AI.qualifier

Table 8.5 IEC 60807-5-101/104 Master AI internal qualifier

Bits	Values	Description
qualifier [xxxx.xxxx]	0...0xFF	AI internal qualifier has 8 data bits
Bit 1	xxxx.xx0x	Additional 'Zero' AI event generation disabled
	xxxx.xx1x	Additional 'Zero' AI event generation enabled . New 0 value event will be generated internally following every: / event with a nonzero value received from outstation and / event with a nonzero value resulted from a deadband/percent or scaling processing. Static AI object will be set to value 0, static value is used when Slave protocol instance responds to an Interrogation or sends AI periodically.
Bit 2	xxxx.x0xx	AI event is generated only if AI object is received from outstation with a 'spontaneous' Cause Of Transmission ([COT] = 3)
	xxxx.x1xx	AI event is generated every time AI object is received from outstation regardless of the Cause Of Transmission. This option is only used for backward compatibility.
Bit 3	xxxx.0xxx	Use original timetag when event is received from outstation
	xxxx.1xxx	Substitute timetag with local time when event is received from outstation
Bit 6	x0xx.xxxx	Process events received from outstation with their original AI value and store original value in the static database. Static value is used when Slave protocol instance responds to an Interrogation or sends AI periodically.
	x1xx.xxxx	Process events received from outstation with their original value, but store 0 value in the static database. Static value is used when Slave protocol instance responds to an Interrogation or sends AI periodically.
Bit 7	0xxx.xxxx	AI is enabled and will be processed when received
	1xxx.xxxx	AI is disabled and will be discarded when received
Bits 0;4;5	Any	Bits reserved for future use

8.2.3 AI.TypeID

Table 8.6 IEC 60807-5-101/104 Slave AI TypeID

TypeID Value for IEC60870-5-101	TypeID Value for IEC60870-5-104	Description
5	5	Static 'Step position Information' will be sent using ASDU type 5 [M_ST_NA_1] AI event will be sent using ASDU type 5 [M_ST_NA_1], no time-tag
6	N/A	Static 'Step position Information' will be sent using ASDU type 5 [M_ST_NA_1] AI event will be sent using ASDU type 6 [M_ST_TA_1], CP24time2A , msec and min
9	9	Static 'Normalized Integer' will be sent using ASDU type 9 [M_ME_NA_1] AI event will be sent using ASDU type 9 [M_ME_NA_1], no time-tag
10	N/A	Static 'Normalized Integer' will be sent using ASDU type 9 [M_ME_NA_1] AI event will be sent using ASDU type 10 [M_ME_TA_1], CP24time2A , msec and min
11	11	Static 'Scaled Integer' will be sent using ASDU type 11 [M_ME_NB_1] AI event will be sent using ASDU type 11 [M_ME_NB_1], no time-tag
12	N/A	Static 'Scaled Integer' will be sent using ASDU type 11 [M_ME_NB_1] AI event will be sent using ASDU type 12 [M_ME_TB_1], CP24time2A , msec and min
13	13	Static 'Short floating point' will be sent using ASDU type 13 [M_ME_NC_1] AI event will be sent using ASDU type 13 [M_ME_NC_1], no time-tag
14	N/A	Static 'Short floating point' will be sent using ASDU type 13 [M_ME_NC_1] AI event will be sent using ASDU type 14 [M_ME_TC_1], CP24time2A , msec and min
32	32	Static 'Step position Information' will be sent using ASDU type 5 [M_ST_NA_1] AI event will be sent using ASDU type 32 [M_ST_TB_1], CP56time2A , full time
34	34	Static 'Normalized Integer' will be sent using ASDU type 9 [M_ME_NA_1] AI event will be sent using ASDU type 34 [M_ME_TD_1], CP56time2A , full time
35	35	Static 'Scaled Integer' will be sent using ASDU type 11 [M_ME_NB_1] AI event will be sent using ASDU type 35 [M_ME_TE_1], CP56time2A , full time
36	36	Static 'Short floating point' will be sent using ASDU type 13 [M_ME_NC_1] AI event will be sent using ASDU type 36 [M_ME_TF_1], CP56time2A , full time
Other	Other	Undefined, default values will be used: IEC 60870-5-101 default ASDU type 14 [M_ME_TC_1], CP24time2A , msec and min IEC 60870-5-104 default ASDU type 36 [M_ME_TF_1], CP56time2A , full time

Tip:

Note, all AI objects are internally stored and processed as 'Short floating point' values. If any other type needs to be reported to the upstream Master station, object is being converted just before it is sent.

8.3 DOTable group and DO node

Group node [DOTable](#) and child element nodes [DO](#) are used to create DO information objects to send control command to the downstream outstation. Each created DO can be used as a destination for any DO information object defined in the IO table of any Slave protocol instance. Command execution procedure is as follows: Slave protocol instance receives a control command from the upstream Master station and forwards to the destination DO information object. Then current communication protocol instance prepares and sends a command to the outstation based on DO settings configured below. Please refer to the section **[DOTable group and DO node](#)** for more information on how to use DO as a destination for command received by the Slave protocol instance.

Every outgoing control command to the downstream outstation must have information address (IOA) specified using [DI.InfAddr](#) attribute.

Please see sample [DOTable](#) group node and [DO](#) child element nodes below. There are 5 DO information objects configured using 4 [DO](#) element nodes.

```
<DOTable>
  <DO Index="0" InfAddr="1" qualifier="0x00" TypeID="45"/>
  <DO Index="1" InfAddr="2" qualifier="0x10" TypeID="46"/>
  <DO Index="2" InfAddr="3" qualifier="0x10" QOC="3"/>
  <DO Index="3" InfAddr="4" qualifier="0x00" Total="2"/>
</DOTable>
```

Please see sample [DO](#) element node below listing all available attributes.

```
<DO Index="0"
  InfAddr="1"
  qualifier="0x00"
  QOC="0"
  TypeID="46"
  Total="2"
  Name="CB command" />
```

Tip:

Attributes of the [DO](#) element node can be arranged in any order, it will not affect the XML file validation.

8.3.1 DO attributes

Table 8.7 IEC 60807-5-101/104 Master DO attributes

Attribute	Values or range	Description
Index	0...2 ³² - 8	Index is a unique identifier of the DO object. Index numbering must start with 0 and indexes must be arranged in an ascending order as it prevents insertion of a new object. This requirement is essential because it affects object mapping to Slave communication protocol instances.
InfAddr	1...16777215	Information Object Address (IOA) of the DO object. This IOA will be used to send control command to downstream outstation. Addresses don't have to be arranged in an ascending order.
qualifier	See table 8.8 for description	Internal object qualifier to enable customized data processing. See table 8.8 for internal object qualifier description. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
QOC	See table 8.10 for description	Qualifier Of Command (QOC) is used to define specify short/long pulse information for the outgoing command. See table 8.10 values. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
TypeID	See table 8.9 for description	Send command with the defined ASDU Type. There is no default value, ASDU TypeID is transparent if neither this attribute nor communication protocol generic attribute (e.g. IEC101ma or IEC104ma ASDUSettings.DOType) is used. Attribute is optional and doesn't have to be included in configuration.
Total	1...16777215	Total number of information objects. Attribute is used to create sequence of information objects with consecutive DO.Index and DO.InfAddr attribute values without a need to create individual DO nodes for each information object. (default value 1; only 1 object is created with this DO node) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

8.3.2 DO.qualifier

Table 8.8 IEC 60807-5-101/104 Master DO internal qualifier

Bits	Values	Description
qualifier [xxxx.xxxx]	0...0xFF	DO internal qualifier has 8 data bits
Bit 0	xxxx.xxx0	DO object will not be inverted
	xxxx.xxx1	DO object will be inverted (OFF → ON; ON → OFF)
Bit 6	x0xx.xxxx	Direct Execute control command will be sent
	x1xx.xxxx	Select and Execute control commands will be sent
Bit 7	0xxx.xxxx	DO is enabled , command will be sent to outstation
	1xxx.xxxx	DO is disabled , command will not be sent to outstation
Bits 1...5	Any	Bits reserved for future use

8.3.3 DO.TypeID

Table 8.9 IEC 60807-5-101/104 Master DO TypeID

TypeID Value	Description
45	'Single command' will be sent (ASDU type 45 [C_SC_NA_1])
46	'Double command' will be sent (ASDU type 46 [C_DC_NA_1])
47	'Regulating step command' will be sent (ASDU type 47 [C_RC_NA_1])
58	Only applicable to IEC60870-5-104 Master protocol instance; Time-tagged 'Single command' will be sent (ASDU type 58 [C_SC_TA_1])
59	Only applicable to IEC60870-5-104 Master protocol instance; Time-tagged 'Double command' will be sent (ASDU type 59 [C_DC_TA_1])
60	Only applicable to IEC60870-5-104 Master protocol instance; Time-tagged 'Regulating step command' will be sent (ASDU type 60 [C_RC_TA_1])
Other	Transparent, ASDU TypeID of the outgoing command will be the same as received from upstream Master station

8.3.4 DO.QOC

Table 8.10 IEC 60807-5-101/104 Master QOC

QOC Values	Description
0	Command will be sent with [no additional definition]
1	Command will be sent with [short-pulse duration]
2	Command will be sent with [long-pulse duration]
3	Command will be sent with [persistent output]
128	Command will be sent with the same information as received from upstream Master station. This is a transparent mode.
4...31	Reserved for [compatible range] and [private range] as per IEC 60870-5-101 standard
Other	Undefined, don't use

8.4 AOTable group and AO node

Group node [AOTable](#) and child element nodes [AO](#) are used to create AO information objects to send setpoint command to the downstream outstation. Each created AO can be used as a destination for any AO information object defined in the IO table of any Slave protocol instance. Command execution procedure is as follows: Slave protocol instance receives a setpoint command from the upstream Master station and forwards to the destination AO information object. Then current communication protocol instance prepares and sends a command to the outstation based on AO settings configured below. Please refer to the section [AOTable group and AO node](#) for more information on how to use AO as a destination for command received by the Slave protocol instance.

Every outgoing control command to the downstream outstation must have information address (IOA) specified using [AO.InfAddr](#) attribute.

Please see sample [AOITable](#) group node and [AO](#) child element nodes below. There are 5 AO information objects configured using 4 [AO](#) element nodes.

```
<AOTable>
  <AO Index="0" InfAddr="1" TypeID="48"/>
  <AO Index="1" InfAddr="2" TypeID="49"/>
  <AO Index="2" InfAddr="3" Coeff="3.3"/>
  <AO Index="3" InfAddr="4" Total="2"/>
</AOTable>
```

Please see sample [AO](#) element node below listing all available attributes.

```
<AO Index="0"
  InfAddr="1"
  qualifier="0x00"
  Coeff="11.6"
  TypeID="50"
  Total="2"
  Name="Filtering value" />
```

Tip:

Attributes of the [AO](#) element node can be arranged in any order, it will not affect the XML file validation.

8.4.1 AO attributes

Table 8.11 IEC 60807-5-101/104 Master AO attributes

Attribute	Values or range	Description
Index	$0 \dots 2^{32} - 8$	Index is a unique identifier of the AO object. Index numbering must start with 0 and indexes must be arranged in an ascending order as it prevents insertion of a new object. This requirement is essential because it affects object mapping to Slave communication protocol instances.
InfAddr	1...16777215	Information Object Address (IOA) of the AO object. This IOA will be used to send setpoint command to downstream outstation. Addresses don't have to be arranged in an ascending order.
qualifier	See table 8.12 for description	Internal object qualifier to enable customized data processing. See table 8.12 for internal object qualifier description. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Coeff	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Coefficient to multiply the setpoint object value before sending to destination outstation. (default value 1) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
TypeID	See table 8.13 for description	Send command with the defined ASDU Type. There is no default value, ASDU TypeID is transparent if neither this attribute nor communication protocol generic attribute (e.g. IEC101ma or IEC104ma ASDUSettings.AOType) is used. Attribute is optional and doesn't have to be included in configuration.
Total	1...16777215	Total number of information objects. Attribute is used to create sequence of information objects with consecutive AO.Index and AO.InfAddr attribute values without a need to create individual AO nodes for each information object. (default value 1; only 1 object is created with this AO node) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

8.4.2 AO.qualifier

Table 8.12 IEC 60807-5-101/104 Master AO internal qualifier

Bits	Values	Description
qualifier [xxxx.xxxx]	0...0xFF	AO internal qualifier has 8 data bits
Bit 6	x0xx.xxxx	Direct-Execute setpoint command will be sent
	x1xx.xxxx	Select and Execute setpoint commands will be sent
Bit 7	0xxx.xxxx	AO is enabled , command will be sent to outstation
	1xxx.xxxx	AO is disabled , command will not be sent to outstation
Bits 0...5	Any	Bits reserved for future use

8.4.3 AO.TypeID

Table 8.13 IEC 60807-5-101/104 Master AO TypeID

TypeID Value	Description
48	'Normalized setpoint command' will be sent (ASDU type 48 [C_SE_NA_1])
49	'Scaled setpoint command' will be sent (ASDU type 49 [C_SE_NB_1])
50	'Short floating point setpoint command' will be sent (ASDU type 50 [C_SE_NC_1])
61	Only applicable to IEC60870-5-104 Master protocol instance; Time-tagged 'Normalized setpoint command' will be sent (ASDU type 61 [C_SE_TA_1])
62	Only applicable to IEC60870-5-104 Master protocol instance; Time-tagged 'Scaled setpoint command' will be sent (ASDU type 62 [C_SE_TB_1])
63	Only applicable to IEC60870-5-104 Master protocol instance; Time-tagged 'Short floating point setpoint command' will be sent (ASDU type 63 [C_SE_TC_1])
Other	Transparent, ASDU TypeID of the outgoing command will be the same as received from upstream Master station

IEC60870-5-103 Master configuration

This section describes how to configure IEC 60870-5-103 controlling station (Master) communication protocol instance. Each IEC 60870-5-103 controlling station (Master) communication protocol instance must have XML configuration file where its IO object table and additional protocol-related settings will be stored. One and the same XML configuration file can be used for multiple IEC 60870-5-103 controlling station (Master) communication protocol instances, this becomes useful in case if identical sets of IO objects are acquired from several outstations.

Name and location path of the XML configuration file are not predefined, they can be chosen freely. File name **'Feeder_F1.xml'** will be used as a sample and location path doesn't need to be specified if XML file is stored in the same directory as leandc firmware. In order to use the XML file for a communication protocol instance, simply enter the name **'Feeder_F1.xml'** in [IEC103ma.XMLpath](#) attribute.

IEC60870-5-103 Master configuration file (e.g. **'Feeder_F1.xml'**) must have a root object node [IEC103maConfig](#) which has 5 child group object nodes [VersionControl](#); [ProtocolCfg](#); [DItable](#); [AITable](#); [DOTable](#) please see the sample below.

```
<IEC103maConfig xmlns="http://www.londelec.com/xmlschemas/leandc/IEC103ma" ... version="1.00">
  <VersionControl conf="4" date="2014-01-18" time="10:08:09"/>
  <ProtocolCfg>
    <CommsSettings OfflineDelay="120" />
    <ASDUSettings SUthroughoutDST="1" />
    ...
  </ProtocolCfg>
  <DItable>
    <DI Index="0" qualifier="0" FUN="240" INF="160"/>
    ...
  </DItable>
  <AITable>
    <AI Index="0" qualifier="0" FUN="134" INF="148" MEA="0" Coeff="0.09" Percent="0.1"/>
    ...
  </AITable>
  <DOTable>
    <DO Index="0" qualifier="0" FUN="240" INF="160" TypeID="0"/>
    ...
  </DOTable>
</IEC103maConfig>
```

[DItable](#); [AITable](#); [DOTable](#) group nodes compose an IO object table of the IEC60870-5-103 controlling station (Master) communication protocol instance. Please refer to the tables [9.8](#); [9.10](#) and [9.12](#) for their attributes.

9.1 ProtocolCfg group node

Protocol-related settings of the IEC60870-5-103 controlling station (Master) communication protocol instance are configured using various child element nodes under [ProtocolCfg](#) group node.

Important:

It is essential to keep element nodes in the listed order otherwise it will affect the XML file validation.

Please see sample [ProtocolCfg](#) group node and the table listing all available child element nodes below.

```
<ProtocolCfg>
  <CommsSettings ... />
  <ASDUSettings ... />
  <Timeouts ... />
  <TimeSettings ... />
  <Broadcast ... />
  <Periodic ... />
</ProtocolCfg>
```

Tip:

All element nodes are optional, default values will be used for attributes of omitted nodes.

Table 9.1 IEC 60807-5-103 Master ProtocolCfg child element nodes

Attribute	Values or range	Description
CommsSettings	See table 9.2	Communication status (e.g. online and offline) change behavior and related delay configuration node. Refer to table 9.2 for attribute specification.
ASDUSettings	See table 9.3	Various application layer settings configuration node. Refer to table 9.3 for attribute specification.
Timeouts	See table 9.4	Control command expiration timeout configuration node. Refer to table 9.4 for attribute specification.
TimeSettings	See table 9.5	Unique time settings (e.g. time zone) of particular protocol instance. Refer to table 9.5 for attribute specification.
Broadcast	See table 9.6	Broadcast or individual common address of ASDU (CAA) specification node. Refer to table 9.6 for attribute specification.
Periodic	See table 9.7	Periodic command generation interval specification node. Refer to table 9.7 for attribute specification.

9.1.1 CommsSettings attributes

Communication state reporting and related delays can be specified using attributes of [CommsSettings](#) element node. Please see sample [CommsSettings](#) node and the table listing all available attributes below.

```
<CommsSettings    NoRespCount="5"
  DegradedRetries="5"
  DegradedTimeout="600"
  ControlLockTimer="20"
  OfflineDelay="10"
  OnlineGIDelay="10"
  OfflineNTDelay="1000"
  DisabledNT="1" />
```

Table 9.2 IEC 60807-5-103 Master CommsSettings attributes

Attribute	Values or range	Description
NoRespCount	1...255	Outstation no-response counter. Station status will be changed to OFFLINE and Invalid [IV] bit of all DI/AI information objects will be set if outstation fails to reply to a configured number of subsequent requests. Outstation status will be changed to OFFLINE immediately unless additional OfflineDelay is specified. (default 5 retries; leandc will retry outgoing message for 5 times before changing outstation status to OFFLINE) (default 5 retries)
DegradedRetries	0...255	Outgoing message retries before activating DegradedTimeout . Outstation will be temporarily excluded from polling if it fails to reply to a configured number of requests. Value 0 disables degraded timeout functionality (default 5 retries)
DegradedTimeout	0...2 ³² - 1	Degraded timeout in seconds. Outstation is excluded from polling for a configured number of seconds if it has failed to reply to a number of requests configured in DegradedRetries node. Value 0 disables degraded timeout functionality (default 600 seconds)
ControlLockTimer	0...120	Control command lock timer is used to poll only one outstation for a configured number of seconds after sending a control command. All other outstations sharing the same hardware channel are temporary excluded from polling while ControlLockTimer operates. This feature allows to speed up reception of a control command feedback. ControlLockTimer can be used only if more than one outstation uses the same hardware channel. Value 0 disables control lock timer feature. (default 30 seconds)
OfflineDelay	0...2 ³² - 1	Offline delay in seconds before outstation status is changed to OFFLINE. Offline delay timer is activated only after outstation has failed to reply to a number of requests configured in NoRespCount node. (example, if this delay is 10, status will be changed to OFFLINE when outstation has failed to reply to a number of requests configured in NoRespCount plus 10 second delay (default 0 seconds)

Continued on next page

Table 9.2 – continued from previous page

Attribute	Values or range	Description
OnlineGIDelay	$0 \dots 2^{32} - 1$	General interrogation command will be delayed by a configured number of seconds when outstation becomes online. Delay is designed to allow outstation to acquire data after reset/power-on and before leandc issues General Interrogation (default value 0)
OfflineNTDelay	$0 \dots 2^{32} - 1$	DI/AI objects will be marked with Not Topical [NT] bit for a configured number of seconds when station goes offline. DI/AI objects will be marked with Invalid [IV] bit after this delay expires. Objects are never marked with Not Topical [NT] bit if this delay is 0. (default 0 seconds)
DisabledNT	0	Mark DI/AI objects with Invalid [IV] bit when communication disable service command is received (default value)
	1	Mark DI/AI objects with Not Topical [NT] bit when communication disable service command is received

9.1.2 ASDUSettings attributes

Application layer settings can be specified using attributes of [ASDUSettings](#) element node.

Please see sample [ASDUSettings](#) node and the table listing all available attributes below.

```
<ASDUSettings InvalidEvent="1"
IgnoreTimetags="1"
SUthroughoutDST="1"
AIDeadband="2"
AIPercent="0.5"
DIEventStartup="1"
AIEventStartup="1" />
```

Table 9.3 IEC 60807-5-103 Master ASDUSettings attributes

Attribute	Values or range	Description
InvalidEvent	0	Events with set Invalid [IV] bit will not be generated
	1	Events with set Invalid [IV] bit will be generated (default value)
IgnoreTimetags	0	Use original timetag when events are received from outstation (default value)
	1	Substitute timetag with the local time when events are received from outstation
SUthroughoutDST	0	Summer Time [SU] bit of any outgoing message timestamp will be set to indicate last hour of the summer time before clock adjustment at the end of DST (when clock is changed one hour back) (default value)
	1	Summer Time [SU] bit of any outgoing message timestamp will always be set if date and time of the timestamp is Summer time. Please note this functionality is deviation from the communication standard and option should be avoided.
AIDeadband	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Deadband for all AI objects which doesn't have AI.Deadband attribute specified in their element node. Refer to individual AI.Deadband attribute description for more information. Value 0 disables deadband feature. (default value 0)
AIPercent	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Percent deadband for all AI objects which doesn't have AI.Percent attribute specified in their element node. Refer to individual AI.Percent attribute description for more information. Value 0 disables percent feature. (default value 0)
DIEventStartup	0	DI events will not be generated when received from outstation for the first time after system startup
	1	DI events will be generated when received from outstation for the first time after system startup (default value)
AIEventStartup	0	AI events will not be generated when received from outstation for the first time after system startup
	1	AI events will be generated when received from outstation for the first time after system startup (default value)

9.1.3 Timeouts attributes

Timeout values can be specified using attributes of [Timeouts](#) element node.

Please see sample [Timeouts](#) node and the table listing all available attributes below.

```
<Timeouts Application="30" Command="10" />
```

Table 9.4 IEC 60807-5-103 Master Timeouts attributes

Attribute	Values or range	Description
Application	$1 \dots 2^{32} - 1$	Application timeout is a delay in seconds for how long communication protocol instance waits response from downstream outstation after control command has been sent. If no response is received within a configured timeout, command is considered to be failed and processing is terminated (command gets removed from the buffer). In general application timeout is used to terminate pending control commands, if communication to downstream outstation is lost. (default 30 seconds)
Command	$1 \dots 2^{32} - 1$	Command timeout is a delay in seconds for how long communication protocol instance tries to send command response to upstream Master station. If it is impossible to send the response within a configured timeout, command is considered to be failed and processing is terminated (command gets removed from the buffer). In general command timeout is used to terminate pending control commands, if communication to upstream Master station is lost. (default 10 seconds)

9.1.4 TimeSettings attributes

Time settings of each communication protocol instance can be specified using attributes of [TimeSettings](#) element node.

Please see sample [TimeSettings](#) node and the table listing all available attributes below.

```
<TimeSettings TimeZone="Europe/Riga" />
```

Table 9.5 IEC 60807-5-103 Master TimeSettings attributes

Attribute	Values or range	Description
TimeZone	Max 200 chars	Adjust incoming and outgoing message timestamps assuming peer station operates within the specified time zone. TimeZone attribute must not be used if not required, there is no default value. Message timestamps will not be adjusted if attribute omitted. Please see Time Zone specification for additional information.

9.1.5 Broadcast attributes

Broadcast common address of ASDU (CAA) usage for various commands can be specified using attributes of [Broadcast](#) element node.

Please see sample [Broadcast](#) node and the table listing all available attributes below.

```
<Broadcast GI="1" TimeSync="0" />
```

Table 9.6 IEC 60807-5-103 Master Broadcast attributes

Attribute	Values or range	Description
GI	0	Send General interrogation commands with individual common addresses of ASDU (CAA) (default value 0)
	1	Send General interrogation commands with broadcast common address of ASDU (CAA). Broadcast address is 255
TimeSync	0	Send Time Synchronization commands with individual link and common addresses of ASDU (CAA) (default value 0)
	1	Send Time Synchronization commands with broadcast link and common address of ASDU (CAA). Broadcast address is 255

9.1.6 Periodic attributes

Periodic intervals of sending various messages can be specified using attributes of [Periodic](#) element node. Please see sample [Periodic](#) node and the table listing all available attributes below.

```
<Periodic GI="600" TimeSync="0" />
```

Table 9.7 IEC 60807-5-103 Master Periodic attributes

Attribute	Values or range	Description
GI	$0 \dots 2^{32} - 1$	Periodic General Interrogation command interval in seconds. Value 0 disables periodic General Interrogation command. (default value 0)
TimeSync	$0 \dots 2^{32} - 1$	Periodic Time synchronization command interval in seconds. Value 0 disables time synchronization command. (default value 0)

9.2 DITable group and DI node

Group node [DITable](#) and child element nodes [DI](#) are used to create DI information objects to receive status information from the downstream outstation. Each created DI information object can be used as source of information for any DI information object defined in IO table of the Slave protocol instances. If used as a source, status information received from an outstation will be forwarded to DI information object of the Slave protocol instance and then to the upstream Master station. Please refer to the section [DITable group and DI node](#) for more information on how to use DI information object as a source.

In order to receive status information from the downstream outstation function type (FUN) and information number (INF) need to be entered in [DI.FUN](#) and [DI.INF](#) attributes.

Please see sample [DITable](#) group node and [DI](#) child element nodes below. There are 5 DI information objects configured using 4 [DI](#) element nodes.

```
<DITable>
  <DI Index="0" FUN="1" INF="1" qualifier="0x00"/>
  <DI Index="1" FUN="1" INF="2" qualifier="0x10"/>
  <DI Index="2" FUN="240" INF="55" qualifier="0x10"/>
  <DI Index="3" FUN="240" INF="56" qualifier="0x00" Total="2"/>
</DITable>
```

Please see sample [DI](#) element node below listing all available attributes.

```
<DI Index="0"
FUN="1"
INF="1"
qualifier="0"
Total="2"
Name="CB position" />
```

Tip:

Attributes of the [DI](#) element node can be arranged in any order, it will not affect the XML file validation.

9.2.1 DI attributes

Table 9.8 IEC 60807-5-103 Master DI attributes

Attribute	Values or range	Description
Index	$0 \dots 2^{32} - 8$	Index is a unique identifier of the DI object. Index numbering must start with 0 and indexes must be arranged in an ascending order as it prevents insertion of a new object. This requirement is essential because it affects object mapping to Slave communication protocol instances.
FUN	0...255	Function Type (FUN) of the DI object. This FUN will be used to receive object from downstream outstation. Function types don't have to be arranged in an ascending order.
INF	0...255	Information Number (INF) of the DI object. This INF will be used to receive object from downstream outstation. Information numbers don't have to be arranged in an ascending order.
qualifier	See table 9.9 for description	Internal object qualifier to enable customized data processing. See table 9.9 for internal object qualifier description. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Total	1...255	Total number of information objects. Attribute is used to create sequence of information objects with consecutive DI.Index and DI.INF attribute values without a need to create individual DI nodes for each information object. (default value 1; only 1 object is created with this DI node) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

9.2.2 DI.qualifier

Table 9.9 IEC 60807-5-103 Master DI internal qualifier

Bits	Values	Description
qualifier [xxxx.xxxx]	0...0xFF	DI internal qualifier has 8 data bits
Bit 0	xxxx.xxx0	DI object will not be inverted (ON = 2; OFF = 1; INTER = 0; INVALID = 3)
	xxxx.xxx1	DI object will be inverted (ON = 1; OFF = 2; INTER = 0; INVALID = 3)
Bit 1	xxxx.xx0x	Additional 'Zero' DI event generation disabled
	xxxx.xx1x	Additional 'Zero' DI event generation enabled . An OFF event will be internally generated following every sent DI ON event. Static DI object will be set to OFF value, static value is used when Slave protocol instance responds to an Interrogation.
Bit 2	xxxx.x0xx	DI event is generated only when object state is changed
	xxxx.x1xx	DI event is generated every time it is received from outstation. Invalid [IV] flag is automatically cleared from these DI objects when outstation becomes online ensuring they are always valid. This option is only used for backward compatibility.
Bit 7	0xxx.xxxx	DI is enabled and will be processed when received
	1xxx.xxxx	DI is disabled and will be discarded when received
Bits 3;6	Any	Bits reserved for future use

9.3 AITable group and AI node

Group node [AITable](#) and child element nodes [AI](#) are used to create AI information objects to receive analog information from the downstream outstation. Each created AI information object can be used as source of information for any AI information object defined in IO table of the Slave protocol instances. If used as a source, analog information received from an outstation will be forwarded to AI information object of the Slave protocol instance and then to the upstream Master station. Please refer to the section [AITable group and AI node](#) for more information on how to use AI information object as a source.

In order to receive analog information from the downstream outstation function type (FUN) and information number (INF) need to be entered in [AI.FUN](#) and [AI.INF](#) Attributes. It also essential to select particular measurement from the incoming message as IEC 60870-5-103 station sends number of measurands in the same message. Particular analog value is selected using [AI.FUN](#) attribute.

Please see sample [AITable](#) group node and [AI](#) child element nodes below. There are 5 AI information objects configured using 4 [AI](#) element nodes.

```
<AITable>
  <AI Index="0" FUN="1" INF="1" MEA="0" qualifier="0x20" Coeff="1.0" Deadband="0.5" Percent="0"/>
  <AI Index="1" FUN="1" INF="1" MEA="5" qualifier="0x00" Coeff="1.0" Deadband="0" Percent="1.4"/>
  <AI Index="2" FUN="85" INF="83" MEA="0" qualifier="0x00" Coeff="-17.0" Percent="1.4"/>
  <AI Index="3" FUN="105" INF="103" MEA="0" qualifier="0x00" Coeff="0.08" Total="2"/>
</AITable>
```

Please see sample [AI](#) element node below listing all available attributes.

```
<AI Index="0"
FUN="85"
INF="83"
MEA="2"
qualifier="0x20"
Coeff="1.0"
Deadband="0.5"
Percent="0"
StartOffset="6554"
ZeroDeadband="3.0"
Offset="-2.0"
OffsetDeadband="2.0"
NonZeroOffset="200.0"
Total="2"
Name="Feeder current" />
```

Tip:

Attributes of the [AI](#) element node can be arranged in any order, it will not affect the XML file validation.

9.3.1 AI attributes

Table 9.10 IEC 60807-5-103 Master AI attributes

Attribute	Values or range	Description
Index	$0 \dots 2^{32} - 8$	Index is a unique identifier of the AI object. Index numbering must start with 0 and indexes must be arranged in an ascending order as it prevents insertion of a new object. This requirement is essential because it affects object mapping to Slave communication protocol instances.
FUN	0...255	Function Type (FUN) of the AI object. This FUN will be used to receive object from downstream outstation. Function types don't have to be arranged in an ascending order.
INF	0...255	Information Number (INF) of the AI object. This INF will be used to receive object from downstream outstation. Information numbers don't have to be arranged in an ascending order.
MEA	0...31	Number of the analog value in the received measurement message. Use the AI.FUN attribute value 0, in order to select the first analog value in the received measurement message. Numbers don't have to be arranged in an ascending order.
qualifier	See table 9.11 for description	Internal object qualifier to enable customized data processing. See table 9.11 for internal object qualifier description. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Coeff	$\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Coefficient to multiply the value of incoming analog object. (default value 1) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Deadband*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Absolute (static) deadband for a real-time analog value. AI value will be updated and an event will be generated if last received analog value exceeds the value stored in the leandc database plus/minus defined Deadband . Defined Deadband is added and subtracted from the analog value stored in the database in order to create absolute deadband range (range is: 'oldvalue - deadband' ... 'oldvalue + deadband'). New incoming analog value is checked against limits of this deadband and an event is generated if value is outside. Value 0 disables deadband feature. (default value 0) Attribute is optional and doesn't have to be included in configuration if not used.

Continued on next page

Table 9.10 – continued from previous page

Attribute	Values or range	Description
Percent*	$\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Percent (dynamic) deadband for a real-time analog value. AI value will be updated and an event will be generated if last received analog value exceeds the value stored in the leandc database plus/minus defined Percent . Defined Percent is used to calculate absolute deadband based on the last analog value stored in the database. When absolute deadband range is calculated, the same procedure as described above applies. Value 0 disables percent deadband feature. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration if not used.</i>
StartOffset*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Start offset normally used to compensate e.g. 4-20mA transducer output range, offset of 4mA. AI will be forced to 0 and IV bit set if a real-time value is below this threshold, otherwise this offset will be subtracted from a real-time value (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
ZeroDeadband*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Zero Deadband is used to filter noise by forcing low AI values to 0. AI will be forced to 0 if its real-time absolute value (+/-) falls below ZeroDeadband attribute. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Offset*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Offset AI value after ZeroDeadband has been applied. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
OffsetDeadband*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Offset Zero Deadband is used to filter noise around 0 value after applying Offset . AI will be forced to 0 if its absolute value (+/-) after offsetting falls below OffsetDeadband attribute. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
NonZeroOffset*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Offset only non-zero values after ZeroDeadband ; Offset and OffsetDeadband has been applied. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Total	1...16777215	Total number of information objects. Attribute is used to create sequence of information objects with consecutive AI.Index and AI.MEA attribute values without a need to create individual AI nodes for each information object. (default value 1; only 1 object is created with this AI node) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Name	Max 100 chars	Freely configurable name, just for reference. <i>Name attribute is optional and doesn't have to be included in configuration.</i>

Tip:

* Please refer to annex **Received AI processing** for additional information on AI processing options and application examples using [AI.Deadband](#); [AI.Percent](#) attributes. Annexes **AI scaling without StartOffset enabled** and **AI scaling with StartOffset enabled** for additional information on AI scaling.

9.3.2 AI.qualifier

Table 9.11 IEC 60807-5-103 Master AI internal qualifier

Bits	Values	Description
qualifier [xxxx.xxxx]	0...0xFF	AI internal qualifier has 8 data bits
Bit 1	xxxx.xx0x	Additional 'Zero' AI event generation disabled
	xxxx.xx1x	Additional 'Zero' AI event generation enabled . New 0 value event will be generated internally following every: / event with a nonzero value received from outstation and / event with a nonzero value resulted from a deadband/percent or scaling processing. Static AI object will be set to value 0, static value is used when Slave protocol instance responds to an Interrogation or sends AI periodically.
Bit 2	xxxx.x0xx	AI event is never generated when object is received from outstation. This setting doesn't affect events resulting from deadband or percent processing.
	xxxx.x1xx	AI event is generated every time AI object is received from outstation. <i>This option is only used for backward compatibility.</i>
Bit 6	x0xx.xxxx	Process events received from outstation with their original AI value and store original value in the static database. Static value is used when Slave protocol instance responds to an Interrogation or sends AI periodically.
	x1xx.xxxx	Process events received from outstation with their original value, but store 0 value in the static database. Static value is used when Slave protocol instance responds to an Interrogation or sends AI periodically.
Bit 7	0xxx.xxxx	AI is enabled and will be processed when received
	1xxx.xxxx	AI is disabled and will be discarded when received
Bits 0;3;4;5	Any	Bits reserved for future use

9.4 DOTable group and DO node

Group node [DOTable](#) and child element nodes [DO](#) are used to create DO information objects to send control command to the downstream outstation. Each created DO information object can be used as a destination for any DO information object defined in IO table of the Slave protocol instances. If used as a destination, procedure is as follows: Slave protocol instance receives control command from the upstream Master station and forwards to destination DO information object. Then current communication protocol instance prepares and sends command to the outstation based on DO information object settings. Please refer to the section [DOTable](#) for more information on how to use DO information object as a destination.

In order to send control command to the downstream outstation function type (FUN) and information number (INF) need to be entered in [DO.FUN](#) and [DO.INF](#) attributes.

Please see sample [DOTable](#) group node and [DO](#) child element nodes below. There are 5 DO information objects configured using 4 [DO](#) element nodes.

```
<DOTable>
  <DO Index="0" FUN="1" INF="1" qualifier="0x00"/>
  <DO Index="1" FUN="1" INF="2" qualifier="0x10"/>
  <DO Index="2" FUN="240" INF="55" qualifier="0x10"/>
  <DO Index="3" FUN="240" INF="56" qualifier="0x00" Total="2"/>
</DOTable>
```

Please see sample [DO](#) element node below listing all available attributes.

```
<DO Index="0"
  FUN="1"
  INF="1"
  qualifier="0x00"
  Total="2"
```

Tip:

Attributes of the [DO](#) element node can be arranged in any order, it will not affect the XML file validation.

9.4.1 DO attributes

Table 9.12 IEC 60807-5-103 Master DO attributes

Attribute	Values or range	Description
Index	0...2 ³² - 8	Index is a unique identifier of the DO object. Index numbering must start with 0 and indexes must be arranged in an ascending order as it prevents insertion of a new object. This requirement is essential because it affects object mapping to Slave communication protocol instances.
FUN	0...255	Function Type (FUN) of the DI object. This FUN will be used to send command to downstream outstation. Function types don't have to be arranged in an ascending order.
INF	0...255	Information Number (INF) of the DI object. This INF will be used to send command to downstream outstation. Information numbers don't have to be arranged in an ascending order.
qualifier	See table 9.13 for description	Internal object qualifier to enable customized data processing. See table 9.13 for internal object qualifier description. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Total	1...255	Total number of information objects. Attribute is used to create sequence of information objects with consecutive DO.Index and DO.INF attribute values without a need to create individual DO nodes for each information object. (default value 1; only 1 object is created with this DO node) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

9.4.2 DO.qualifier

Table 9.13 IEC 60807-5-103 Master DO internal qualifier

Bits	Values	Description
qualifier [xxxx.xxxx]	0...0xFF	DO internal qualifier has 8 data bits
Bit 0	xxxx.xxx0	DO object will not be inverted
	xxxx.xxx1	DO object will be inverted (OFF → ON; ON → OFF)
Bit 7	0xxx.xxxx	DO is enabled , command will be sent to outstation
	1xxx.xxxx	DO is disabled , command will not be sent to outstation
Bits 1...6	Any	Bits reserved for future use

Modbus Master configuration

This section describes how to configure Modbus RTU/ASCII/TCP Master communication protocol instance. Each Modbus Master communication protocol instance must have XML configuration file where its IO object table and additional protocol-related settings are stored. XML configuration file can be used for multiple Modbus Master communication protocol instances, this becomes useful in case if multiple outstations have identical sets of IO objects.

Name and location path of the XML configuration file is not predefined, it can be chosen freely. File name '**Device_IO.xml**' will be used as a sample. Location path doesn't need to be specified if XML file is stored in the same directory as leandc firmware. In order to use the XML file for a communication protocol instance, simply enter the name '**Device_IO.xml**' in [Modbusma.XMLpath](#) attribute.

Modbus Master configuration file (e.g. '**Device_IO.xml**') must have a root object node [ModbusmaConfig](#) which has 2 mandatory child group object nodes [VersionControl](#); [ProtocolCfg](#) and 3 optional child group object nodes [DITable](#); [AITable](#); [DOTable](#) please see the sample below.

```
<ModbusmaConfig xmlns="http://www.londelec.com/xmlschemas/leandc/Modbusma" ... version="1.00">
  <VersionControl conf="4.00" date="2014-11-25" time="12:00:09"/>
  <ProtocolCfg>
    <LinkSettings Type="RTU" />
    <CommsSettings NoRespCount="5" DegradedRetries="3" DegradedTimeout="60" OfflineDelay="10" />
    <Hardcoded Type="BCAIIIS8" />
    ...
  </ProtocolCfg>
  <DITable>
    <DI Index="0" qualifier="0" Total="2"/>
    ...
  </DITable>
  <AITable>
    <AI Index="0" qualifier="0" Coeff="0.09" Deadband="0.1"/>
    ...
  </AITable>
  <DOTable>
    <DO Index="0" qualifier="0" Total="2"/>
    ...
  </DOTable>
</ModbusmaConfig>
```

[DITable](#); [AITable](#); [DOTable](#) group nodes compose an IO object table of the Modbus Master communication protocol instance. Please refer to the tables [10.8](#); [10.9](#) and [10.10](#) for their attributes.

10.1 ProtocolCfg group node

Protocol-related settings of the Modbus Master communication protocol instance are configured using various child element nodes under [ProtocolCfg](#) group node.

Important:

It is essential to keep element nodes in the listed order otherwise it will affect the XML file validation.

Please see sample [ProtocolCfg](#) group node and the table listing all available child element nodes below.

```
<ProtocolCfg>
  <LinkSettings ... />
  <CommsSettings ... />
  <Hardcoded ... />
  <AppSettings ... />
  <Timeouts ... />
</ProtocolCfg>
```

Tip:

All element nodes are optional, default values will be used for attributes of omitted nodes.

Table 10.1 Modbus Master ProtocolCfg child element nodes

Attribute	Values or range	Description
LinkSettings	See table 10.2	Communication link settings configuration node. Refer to section LinkSettings Attributes for detailed specification.
CommsSettings	See table 10.3	Communication status (e.g. online and offline) reporting and related delay configuration node. Refer to section CommsSettings Attributes for detailed specification.
Hardcoded	See table 10.4	Predefined Modbus device specification node. Refer to section Hardcoded Attributes for detailed specification.
AppSettings	See table 10.6	Various application layer settings configuration node. Refer to section AppSettings Attributes for detailed specification.
Timeouts	See table 10.7	Various timeout configuration node. Refer to section Timeouts Attributes for detailed specification.

10.1.1 LinkSettings attributes

Link layer settings can be specified using attributes of [LinkSettings](#) element node.
Please see sample [LinkSettings](#) node and the table listing all available attributes below.

```
<LinkSettings Frame="RTU" />
```

Table 10.2 Modbus Master LinkSettings attributes

Attribute	Values or range	Description
Frame	RTU*	Frame format of the Modbus messages. (default RTU) Please note frame format of all protocol instances sharing the hardware node must be the same.

Important:
* Only ModbusRTU frame format is available in the current release of leandc firmware, more formats to be added in the future.

10.1.2 CommsSettings attributes

Communication state reporting and related delays can be specified using attributes of [CommsSettings](#) element node. Please see sample [CommsSettings](#) node and the table listing all available attributes below.

```
<CommsSettings NoRespCount="5"
  DegradedRetries="5"
  DegradedTimeout="600"
  OfflineDelay="10" />
```

Table 10.3 Modbus Master CommsSettings attributes

Attribute	Values or range	Description
NoRespCount	1...255	Outstation no-response counter. Station status will be changed to OFFLINE and Invalid [IV] bit of all DI/AI information objects will be set if outstation fails to reply to a configured number of subsequent requests. Outstation status will be changed to OFFLINE immediately unless additional OfflineDelay is specified. (default 5 retries; leandc will retry outgoing message for 5 times before changing outstation status to OFFLINE) (default 5 retries)
DegradedRetries	0...255	Outgoing message retries before activating DegradedTimeout . Outstation will be temporarily excluded from polling if it fails to reply to a configured number of requests. Value 0 disables degraded timeout functionality (default 5 retries)
DegradedTimeout	0...2 ³² - 1	Degraded timeout in seconds. Outstation is excluded from polling for a configured number of seconds if it has failed to reply to a number of requests configured in DegradedRetries attribute. Value 0 disables degraded timeout functionality (default 600 seconds)
OfflineDelay	0...2 ³² - 1	Delay in seconds before outstation status is changed to OFFLINE. Offline delay timer is activated only after outstation has failed to reply to a number of requests configured in NoRespCount attribute. (example, if this delay is 10, status will be changed to OFFLINE when outstation has failed to reply to a number of requests configured in NoRespCount plus 10 second delay (default 0 seconds)

10.1.3 Hardcoded attributes

Hardcoded device type can be specified using attributes of [Hardcoded](#) element node.
Please see sample [Hardcoded](#) node and the table listing all available attributes below.

```
<Hardcoded Type="BCDI16" />
```

Table 10.4 Modbus Master Hardcoded attributes

Attribute	Values or range	Description
Type	See table 10.5	Predefined type of the Modbus device. Messages and communication sequences are hardcoded for devices of these types.

10.1.4 Hardcoded types

Table 10.5 Modbus Master Hardcoded Device Types

Type	Description
BCDI16	Brainchild Digital Input (16) module DI16. Number of information objects automatically created for this device: DI=16, AI=0, DO=0
BCAIIS16	Brainchild isolated Analog Input (8) module AIIS8. Number of information objects automatically created for this device: DI=0, AI=8, DO=0
LEDOM16	Londelec Digital Output (16) module DOM16. Number of information objects automatically created for this device: DI=0, AI=0, DO=16
Other	Undefined, none of hardcoded device types will be used

10.1.5 AppSettings attributes

Application layer settings can be specified using attributes of [AppSettings](#) element node.
Please see sample [AppSettings](#) node and the table listing all available attributes below.

```
<AppSettings AIDeadband="2" AIPercent="0.5" />
```

Table 10.6 Modbus Master AppSettings attributes

Attribute	Values or range	Description
AIDeadband	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Deadband for all AI objects which doesn't have AI.Deadband attribute specified in their element node. Refer to individual AI.Deadband attribute description for more information. Value 0 disables deadband feature. (default value 0)
AIPercent	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Percent deadband for all AI objects which doesn't have AI.Percent attribute specified in their element node. Refer to individual AI.Percent attribute description for more information. Value 0 disables percent feature. (default value 0)

10.1.6 Timeouts attributes

Timeout values can be specified using attributes of [Timeouts](#) element node.

Please see sample [Timeouts](#) node and the table listing all available attributes below.

```
<Timeouts Application="30" Command="10" t35="0.01" />
```

Table 10.7 Modbus Master Timeouts attributes

Attribute	Values or range	Description
Application	$1 \dots 2^{32} - 1$	Application timeout is a delay in seconds for how long communication protocol instance waits response from downstream outstation after control command has been sent. If no response is received within a configured timeout, command is considered to be failed and processing is terminated (command gets removed from the buffer). In general application timeout is used to terminate pending control commands, if communication to downstream outstation is lost. (default 30 seconds)
Command	$1 \dots 2^{32} - 1$	Command timeout is a delay in seconds for how long communication protocol instance tries to send command response to upstream Master station. If it is impossible to send the response within a configured timeout, command is considered to be failed and processing is terminated (command gets removed from the buffer). In general command timeout is used to terminate pending control commands, if communication to upstream Master station is lost. (default 10 seconds)
t35	0.00001...42949	Receive line idle detection timer (t3.5 in the communication standard). Incoming message analyze begins when idle in the receive line exceeds configured number of seconds. (default 0.01 seconds)

10.2 DITable group and DI node

Group node [DITable](#) and child element nodes [DI](#) are used to create DI information objects to receive status information from downstream outstation. Each created DI information object can be used as source of information for any DI information object defined in IO table of the Slave protocol instances. If used as a source, status information received from an outstation will be forwarded to DI information object of the Slave protocol instance and then to the upstream Master station. Please refer to section [DITable group and DI node](#) for more information on how to use DI information object as a source.

Tip:

[DITable](#) group and [DI](#) element nodes are optional if hardcoded Modbus device [Type](#) is used. DI information objects will be automatically initialized for these devices.

Please see sample [DITable](#) group node and [DI](#) child element nodes below. There are 5 DI information objects configured using 4 [DI](#) element nodes.

```
<DITable>
  <DI Index="0" qualifier="0x00"/>
  <DI Index="1" qualifier="0x10"/>
  <DI Index="2" qualifier="0x10"/>
  <DI Index="3" qualifier="0x00" Total="2"/>
</DITable>
```

Please see sample [DI](#) element node below listing all available attributes.

```
<DI Index="0"
  qualifier="0"
  Total="2"
  Name="Transducer mode" />
```

Tip:

Attributes of the [DI](#) element node can be arranged in any order, it will not affect XML file validation.

10.2.1 DI attributes

Table 10.8 Modbus Master DI attributes

Attribute	Values or range	Description
Index	0...2 ³² - 8	Index is a unique identifier of the DI object. Index numbering must start with 0 and indexes must be arranged in an ascending order as it prevents insertion of a new object. This requirement is essential because it affects object mapping to Slave communication protocol instances.
qualifier	0...255	Internal object qualifier to enable customized data processing. (default value 0) Attribute is not implemented currently and reserved for future use.
Total	1...255	Sequence of identical DI objects. Attribute is used to create sequence of information objects with consecutive Index attributes. This eliminates the need to create individual DI nodes for each information object. (default value 1; only 1 object is created with this DI node) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

10.3 AITable group and AI node

Group node [AITable](#) and child element nodes [AI](#) are used to create AI information objects to receive analog information from downstream outstation. Each created AI information object can be used as source of information for any AI information object defined in IO table of the Slave protocol instances. If used as a source, analog information received from an outstation will be forwarded to AI information object of the Slave protocol instance and then to the upstream Master station. Please refer to section [AITable group and AI node](#) for more information on how to use AI information object as a source.

Tip:

[AITable](#) group and [AI](#) element nodes are optional if hardcoded Modbus device [Type](#) is used. AI information objects will be automatically initialized for these devices.

Please see sample [AITable](#) group node and [AI](#) child element nodes below. There are 5 AI information objects configured using 4 [AI](#) element nodes.

```
<AITable>
  <AI Index="0" qualifier="0x20" Coeff="1.0" Deadband="0.5" Percent="0"/>
  <AI Index="1" qualifier="0x00" Coeff="1.0" Deadband="0" Percent="1.4"/>
  <AI Index="2" qualifier="0x00" Coeff="-17.0" Percent="1.4"/>
  <AI Index="3" qualifier="0x00" Coeff="0.08" Total="2"/>
</AITable>
```

Please see sample [AI](#) element node below listing all available attributes.

```
<AI Index="0"
  qualifier="0x20"
  Coeff="1.0"
  Deadband="0.5"
  Percent="0"
  StartOffset="6554"
  ZeroDeadband="3.0"
  Offset="-2.0"
  OffsetDeadband="2.0"
  NonZeroOffset="200.0"
  Total="2"
  Name="Feeder current" />
```

Tip:

Attributes of the [AI](#) element node can be arranged in any order, it will not affect XML file validation.

10.3.1 AI attributes

Table 10.9 Modbus Master AI attributes

Attribute	Values or range	Description
Index	$0 \dots 2^{32} - 8$	Index is a unique identifier of the AI object. Index numbering must start with 0 and indexes must be arranged in an ascending order as it prevents insertion of a new object. This requirement is essential because it affects object mapping to Slave communication protocol instances.
qualifier	0...255	Internal object qualifier to enable customized data processing. (default value 0) Attribute is not implemented currently and reserved for future use.
Coeff	$\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Coefficient to multiply the value of incoming analog object. (default value 1) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Deadband*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Absolute (static) deadband for a real-time analog value. AI value will be updated and an event will be generated if last received analog value exceeds the value stored in the leandc database plus/minus defined Deadband . Defined Deadband is added and subtracted from the analog value stored in the database in order to create absolute deadband range (range is: 'oldvalue - deadband' ... 'oldvalue + deadband'). New incoming analog value is checked against limits of this deadband and an event is generated if value is outside. Value 0 disables deadband feature. (default value 0) Attribute is optional and doesn't have to be included in configuration if not used.
Percent*	$\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Percent (dynamic) deadband for a real-time analog value. AI value will be updated and an event will be generated if last received analog value exceeds the value stored in the leandc database plus/minus defined Percent . Defined Percent is used to calculate absolute deadband based on the last analog value stored in the database. When absolute deadband range is calculated, the same procedure as described above applies. Value 0 disables percent deadband feature. (default value 0) Attribute is optional and doesn't have to be included in configuration if not used.
StartOffset*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Start offset normally used to compensate e.g. 4-20mA transducer output range, offset of 4mA. AI will be forced to 0 and IV bit set if a real-time value is below this threshold, otherwise this offset will be subtracted from a real-time value (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
ZeroDeadband*	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Zero Deadband is used to filter noise by forcing low AI values to 0. AI will be forced to 0 if its real-time absolute value (+/-) falls below ZeroDeadband attribute. (default value 0) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.

Continued on next page

Table 10.9 – continued from previous page

Attribute	Values or range	Description
Offset *	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Offset AI value after ZeroDeadband has been applied. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
OffsetDeadband *	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Offset Zero Deadband is used to filter noise around 0 value after applying Offset . AI will be forced to 0 if its absolute value (+/-) after offsetting falls below OffsetDeadband attribute. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
NonZeroOffset *	0 or $\pm 1.18 \times 10^{-38} \dots \pm 3.4 \times 10^{38}$	Offset only non-zero values after ZeroDeadband ; Offset and OffsetDeadband has been applied. (default value 0) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Total	1...16777215	Sequence of identical AI objects. Attribute is used to create sequence of information objects with consecutive Index attributes. This eliminates the need to create individual AI nodes for each information object. (default value 1; only 1 object is created with this AI node) <i>Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.</i>
Name	Max 100 chars	Freely configurable name, just for reference. <i>Name attribute is optional and doesn't have to be included in configuration.</i>

Tip:

* Please refer to annex **Received AI processing** for additional information on AI processing options and application examples using [Deadband](#); [Percent](#) attributes. Annexes **AI scaling without StartOffset enabled** and **AI scaling with StartOffset enabled** for additional information on AI scaling.

10.4 DOTable group and DO node

Group node [DOTable](#) and child element nodes [DO](#) are used to create DO information objects to send control commands to downstream outstation. Each created DO information object can be used as a destination for any DO information object defined in IO table of the Slave protocol instances. If used as a destination, procedure is as follows: Slave protocol instance receives control command from the upstream Master station and forwards to this destination DO information object. Then current communication protocol instance prepares and sends command to the outstation based on the DO information object settings. Please refer to the section [DOTable group and DO node](#) for more information on how to use DO information object as a destination.

Tip:

[DOTable](#) group and [DO](#) element nodes are optional if hardcoded Modbus device [Type](#) is used. DO information objects will be automatically initialized for these devices.

Please see sample [DOTable](#) group node and [DO](#) child element nodes below. There are 5 DO information objects configured using 4 [DO](#) element nodes.

```
<DOTable>
  <DO Index="0" qualifier="0x00"/>
  <DO Index="1" qualifier="0x10"/>
  <DO Index="2" qualifier="0x10"/>
  <DO Index="3" qualifier="0x00" Total="2"/>
</DOTable>
```

Please see sample [DO](#) element node below listing all available attributes.

```
<DO Index="0"
  qualifier="0x00"
  Total="2"
```

Tip:

Attributes of the [DO](#) element node can be arranged in any order, it will not affect XML file validation.

10.4.1 DO attributes

Table 10.10 Modbus Master DO attributes

Attribute	Values or range	Description
Index	0...2 ³² - 8	Index is a unique identifier of the DO object. Index numbering must start with 0 and indexes must be arranged in an ascending order as it prevents insertion of a new object. This requirement is essential because it affects object mapping to Slave communication protocol instances.
qualifier	0...255	Internal object qualifier to enable customized data processing. (default value 0) Attribute is not implemented currently and reserved for future use.
Total	1...255	Sequence of identical DO objects. Attribute is used to create sequence of information objects with consecutive Index attributes. This eliminates the need to create individual DO nodes for each information object. (default value 1; only 1 object is created with this DO node) Attribute is optional and doesn't have to be included in configuration, default value will be used if omitted.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

Logfile configuration file lelogger.xml

Leandc features an option to record raw communication protocol traffic or decoded application level information to logfiles for supervision and maintenance purposes. XML configuration file with a fixed file name **lelogger.xml** contains all settings related to logfiles. The configuration file must be stored in the same directory as leandc firmware and its path can't be changed.

lelogger.xml configuration file consists of a root object node [SystemConfig](#) which has 3 optional child group object nodes [VersionControl](#); [CommsCfg](#); [EventCfg](#), please see the sample below.

```
<SystemConfig xmlns="http://www.londelec.com/xmlschemas/leandc/lelogger" ... version="1.00">
  <VersionControl conf="4" date="2014-01-18" time="10:08:09"/>
  <CommsCfg>
    <LOGGER Index="6" LogFlags="0x7F" Logfile="Log/ma2"/>
    ...
  </CommsCfg>
  <EventCfg>
    <EVENTLOG Index="104" LogFlags="0x3F" HourLimit="0" Logfile="Events/SL104_1"/>
    ...
  </EventCfg>
</SystemConfig>
```

Tip:

lelogger.xml configuration file is optional and system is able to run normally without it.
Node names are not case sensitive.

11.1 CommsCfg group and LOGGER; HWLOG nodes

Group node [CommsCfg](#) and child element nodes [LOGGER](#); [HWLOG](#) are used to configure raw communication protocol traffic recording to logfiles. There are two options:

- Record all raw traffic on a serial/Ethernet interface;
- Record the traffic only related to a particular communication protocol instance.

[LOGGER](#) node is used to record traffic only related to a specific communication protocol instance. [HWLOG](#) node on the other hand is used to record all traffic on a serial/Ethernet interface. These two methods become very useful and provide flexible filtering options in case more than 1 communication protocol instance share the same hardware interface (e.g. IEC 60870-5-101 controlling station (Master) instances communicating to multiple outstations).

Please see sample [CommsCfg](#) group node and [LOGGER](#); [HWLOG](#) child element nodes below. The sample contains configuration of 2 individual communication protocol instance logfiles and 1 serial interface logfile.

```
<CommsCfg>
  <LOGGER Index="5" LogFlags="0x00" Mode="0x00" HourLimit="4" Logfile="Log/101slave"/>
  <LOGGER Index="6" LogFlags="255" Logfile="Log/104logserv"/>
  <HWLOG HWIndex="1" LogFlags="0x06" Mode="0x00" HourLimit="0" Logfile="Log/COM1"/>
</CommsCfg>
```

Please see sample [LOGGER](#) and [HWLOG](#) element node below listing all available attributes.

```
<LOGGER  Index="5"
  LogFlags="0xFF"
  Mode="0"
  HourLimit="4"
  Logfile="Log/101slave"
  Name="IED logfile" />

<HWLOG  HWIndex="1"
  LogFlags="0x06"
  Mode="0"
  HourLimit="4"
  Logfile="Log/COM1"
  Name="Port logfile" />
```

Tip:

Attributes of the [LOGGER](#) and [HWLOG](#) element nodes can be arranged in any order, it will not affect the XML file validation.

11.1.1 LOGGER and HWLOG attributes

Table 11.1 LOGGER and HWLOG attributes

Attribute	Values or range	Description
Index	1...254	Index attribute is used to enable logging for a particular communication protocol instance. Use value of the Index attribute of any communication protocol instance in order to enable logging. Attribute is mandatory for LOGGER node, it is not required for HWLOG node. Indexes don't have to be in a sequential order.
HWIndex	1...254	Index attribute is used to enable logging for a hardware node. Use value of the UART.Index ; TCPSERVER.Index ; TCPCLIENT.Index or UDP.Index attribute in order to enable logging. Attribute is mandatory for HWLOG node, it is not required for LOGGER node. Indexes don't have to be in a sequential order.
LogFlags	See table 11.2 for description	Log flags specify type of information to be recorded to the logfile. Logfile will not be created, if value is 0.
Logfile	Max 200 chars	Logfile name without an extension, but including absolute or relative path. Logfile will be created in the same folder as leandc firmware if path is not specified. The date and extension 'log' will be added to the file name automatically. Logfile will not be created if attribute is left blank. (default entry 'Log/aaa', where 'aaa' is name of the file) Attribute is case sensitive, observe the case of path and file name when specifying.
Mode*	See table 11.5 for description	New logfile initialization settings. (default value 0) Attribute is optional and doesn't have to be included in configuration, default settings will be used if omitted.
HourLimit*	0...12	New file will be created after selected number of hours in order to limit the size. (default 4 hours) Attribute is optional and doesn't have to be included in configuration, default settings will be used if omitted.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

Tip:

* Please refer to the ([ref](#)) for sample list of files created with various [LOGGER.HourLimit](#) and [LOGGER.Mode](#) attribute settings.

11.1.2 LOGGER.LogFlags

Table 11.2 LOGGER LogFlags

Bits	Values	Description
LogFlags [xxxx.xxxx]	0...0xFF	LogFlags is 8 bit encoded variable. Logfile will not be created, if value is 0
Bit 0	xxxx.xxx0	Link layer (of the IEC60870-5-101 communication protocol) or Transport layer (of the IEC60870-5-104 communication protocol) message recording disabled
	xxxx.xxx1	Link layer (of the IEC60870-5-101 communication protocol) or Transport layer (of the IEC60870-5-104 communication protocol) message recording enabled
Bit 1	xxxx.xx0x	Incoming message recording disabled
	xxxx.xx1x	Incoming message recording enabled
Bit 2	xxxx.x0xx	Outgoing message recording disabled
	xxxx.x1xx	Outgoing message recording enabled
Bit 4	xxx0.xxxx	Socket connection status and [Started]; [Stopped] state information for IEC60870-5-104 protocol instances or link layer state information for IEC60870-5-101 protocol instances recording disabled
	xxx1.xxxx	Socket connection status and [Started]; [Stopped] state information for IEC60870-5-104 protocol instances or link layer state information for IEC60870-5-101 protocol instances recording enabled
Bit 7	0xxx.xxxx	Only applicable to IEC60870-5-101 protocol instances; transmitted message echo (if it exists) will not be recorded to a logfile
	1xxx.xxxx	Only applicable to IEC60870-5-101 protocol instances; transmitted message echo (if it exists) will be recorded to a logfile
Bits 3;5;6	Any	Bits reserved for future use

11.2 EventCfg group and EVENTLOG; HWEVENTLOG node

Group node [EventCfg](#) and child element nodes [EVENTLOG](#); [HWEVENTLOG](#) are used to configure decoded application level information (DI/AI/DO object types, addresses, values, etc) recording to logfiles. There are two options:

- Record all decoded information on a serial/Ethernet interface;
- Record the decoded information only related to a particular communication protocol instance.

[EventCfg](#) node is used to record decoded information only related to a specific communication protocol instance. [HWEVENTLOG](#) node on the other hand is used to record all decoded information on a serial/Ethernet interface. These two methods become very useful and provide flexible filtering options in case more than 1 communication protocol instance share the same hardware interface (e.g. IEC 60870-5-101 controlling station (Master) instances communicating to multiple outstations).

Please see sample [EventCfg](#) group node and [EVENTLOG](#); [HWEVENTLOG](#) child element nodes below. The sample contains configuration of 2 individual communication protocol instance logfiles and 1 serial interface logfile.

```
<EventCfg>
  <EVENTLOG Index="5" LogFlags="0x3F" HourLimit="0" Mode="0" Logfile="Events/101slave"/>
  <EVENTLOG Index="6" LogFlags="0x0C" Logfile="Events/101slave_test2"/>
  <HWEVENTLOG HWIndex="1" LogFlags="0x40" HourLimit="0" Logfile="Events/COM1_events"/>
</EventCfg>
```

Please see sample [EVENTLOG](#) and [HWEVENTLOG](#) element node below listing all available attributes.

```
<EVENTLOG Index="5"
  LogFlags="0xFF"
  Mode="0"
  HourLimit="4"
  Logfile="Events/101slave"
  Name="IED Events" />

<HWEVENTLOG HWIndex="1"
  LogFlags="0x06"
  Mode="0"
  HourLimit="4"
  Logfile="Events/COM1"
  Name="All IED Events" />
```

Tip:

Attributes of the [EVENTLOG](#) and [HWEVENTLOG](#) element nodes can be arranged in any order, it will not affect the XML file validation.

11.2.1 EVENTLOG and HWEVENTLOG attributes

Table 11.3 EVENTLOG and HWEVENTLOG attributes

Attribute	Values or range	Description
Index	1...254	Index attribute is used to enable logging for a particular communication protocol instance. Use value of the Index attribute of any communication protocol instance in order to enable logging. Attribute is mandatory for EVENTLOG node, it is not required for HWEVENTLOG node. Indexes don't have to be in a sequential order.
HWIndex	1...254	Index attribute is used to enable logging for a hardware node. Use value of the UART.Index ; TCPSERVER.Index ; TCPCLIENT.Index or UDP.Index attribute in order to enable logging. Attribute is mandatory for EVENTLOG node, it is not required for HWEVENTLOG node. Indexes don't have to be in a sequential order.
LogFlags	See table 11.4 for description	Log flags specify type of information to be recorded to the logfile. Logfile will not be created, if value is 0.
Logfile	Max 200 chars	Event logfile name without an extension, but including absolute or relative path. Logfile will be created in the same folder as leandc firmware if path is not specified. The date and extension 'event' will be added to the file name automatically. Logfile will not be created if attribute is left blank. (default entry 'Events/aaa', where 'aaa' is name of the file) Attribute is case sensitive, observe the case of path and file name when specifying.
Mode *	See table 11.5 for description	New logfile initialization settings. (default value 1) Attribute is optional and doesn't have to be included in configuration, default settings will be used if omitted.
HourLimit *	0...12	New file will be created after selected number of hours in order to limit the size. (default 6 hours) Attribute is optional and doesn't have to be included in configuration, default settings will be used if omitted.
Name	Max 100 chars	Freely configurable name, just for reference. Name attribute is optional and doesn't have to be included in configuration.

Tip:

* Please refer to the ([ref](#)) for sample list of files created with various [EVENTLOG.HourLimit](#) and [EVENT-LOG.Mode](#) attribute settings.

11.2.2 EVENTLOG.LogFlags

Table 11.4 EVENTLOG LogFlags

Bits	Values	Description
LogFlags [xxxx.xxxx]	0...0xFF	LogFlags is 8 bit encoded variable. Logfile will not be created, if value is 0
Bit 0	xxxx.xxx0	Received/sent spontaneous (event) DI information will not be recorded to event logfile
	xxxx.xxx1	Received/sent spontaneous (event) DI information will be recorded to event logfile
Bit 1	xxxx.xx0x	Received/sent spontaneous (event) AI information will not be recorded to event logfile
	xxxx.xx1x	Received/sent spontaneous (event) AI information will be recorded to event logfile
Bit 2	xxxx.x0xx	Received/sent control/setpoint command information will not be recorded to event logfile
	xxxx.x1xx	Received/sent control/setpoint command information will be recorded to event logfile
Bit 3	xxxx.0xxx	Processed command information and related error messages will not be recorded to event logfile
	xxxx.1xxx	Processed command information and related error messages will be recorded to event logfile
Bit 4	xxx0.xxxx	Received/sent static (General Interrogation) DI information will not be recorded to event logfile
	xxx1.xxxx	Received/sent static (General Interrogation) DI information will be recorded to event logfile
Bit 5	xx0x.xxxx	Received/sent static (General Interrogation) AI information will not be recorded to event logfile
	xx1x.xxxx	Received/sent static (General Interrogation) AI information will be recorded to event logfile
Bit 6	x0xx.xxxx	Received/sent cyclic AI information will not be recorded to event logfile
	x1xx.xxxx	Received/sent cyclic AI information will be recorded to event logfile
Bit 7	Any	Bits reserved for future use

11.2.3 **LOGGER.Mode** and **EVENTLOG.Mode**

Table 11.5 Mode attribute

Bits	Values	Description
Mode [xxxx.xxxx]	0...0xFF	Mode is 8 bit encoded variable
Bit 0	xxxx.xxx0	New logfile will be created each time leandc firmware is being started/restarted
	xxxx.xxx1	New logfile will not be created, providing a logfile with the same date string already exists upon leandc firmware start/restart. In this case new entries will be appended to the end of the existing logfile.
Bits 1...6	Any	Bits reserved for future use

Please note new communication traffic logfile will be created every time leandc firmware is started/restarted, if [LOGGER.Mode](#) attribute is 0 (default value). [LOGGER.HourLimit](#) attribute controls the interval of creating new logfile if leandc firmware is running without being restarted. By default new logfile is created every 4 hours ([LOGGER.HourLimit](#) default value).

Tip:

File creation date and hour (format yyyy-mm-dd_hh) is added to the name of the file specified in [LOGGER.Logfile](#). Please see sample list of files created, if leandc firmware is running without being restarted.

- 'logfile_2013-04-12_00.log'
- 'logfile_2013-04-12_04.log'
- 'logfile_2013-04-12_08.log'
- 'logfile_2013-04-12_12.log'

Time tag (format hhmmss) is also added to the name of the file specified in [LOGGER.Logfile](#), if leandc firmware restarts. Please see sample list of files created, if leandc firmware is being restarted at 14:04:13 and 14:07:32.

- 'logfile_2013-04-12_12.log'
- 'logfile_2013-04-12_140413.log'
- 'logfile_2013-04-12_140732.log'
- 'logfile_2013-04-12_16.log'

Default settings for application level information event files are slightly different. New event file will not be created upon leandc firmware restart, if [EVENTLOG.Mode](#) attribute is 1 (default value). New entries are appended to an existing file after firmware restart. [EVENTLOG.HourLimit](#) attribute controls the interval of creating new event file if leandc firmware is running without being restarted. By default new event file is created every 6 hours ([EVENTLOG.HourLimit](#) default value).

Tip:

File creation date and hour (format yyyy-mm-dd_hh) is added to the name of the file specified in [EVENTLOG.Logfile](#). Please see sample list of files created, regardless if leandc firmware is being restarted or not.

- '104events_2013-04-12_00.event'
- '104events_2013-04-12_06.event'
- '104events_2013-04-12_12.event'
- '104events_2013-04-12_18.event'

Configuration version control

All XML configuration files must contain version control element node where user can enter a unique number to control configuration file version along with file creation date and time. Each configuration file has its own version number and it is not related to any other XML files. If particular XML file is being modified by web configuration tool, the version number is automatically incremented by 1 and modification date and time is recorded.

Version control node must have 3 attributes [conf](#); [date](#); [time](#) please see the sample below.

```
<VersionControl conf="4" date="2014-01-18" time="10:08:09"/>
```

12.1 VersionControl attributes

Table 12.1 VersionControl attributes

Attribute	Values or range	Description
conf	0.01...65535	User assigned version number of the particular XML file. Number will be automatically incremented by 1 when particular XML file is being modified by web configuration tool.
date	date format YYYY-MM-DD	Date when particular configuration file was created or modified.
time	time format HH:MM:SS	Time when particular configuration file was created or modified.

Important:

All attributes are mandatory.

Annexes

13.1 Analog value processing

This annex contains additional information on incoming AI processing, scaling options and application examples.

13.1.1 AI scaling without StartOffset enabled

Flowchart on the right shows scaling sequence when leandc receives AI value from outstation or before sending AI value to upstream station depending on used communication protocol. Scaling sequence shown below is used if *StartOffset* is **not enabled** (attribute *AI.StartOffset* = 0 or excluded). Sample values before and after each step are listed in the following tables. Please note there is no relation between values shown in different tables. Tables are used to illustrate functionality of each step separately not the complete operation of the scaling sequence.

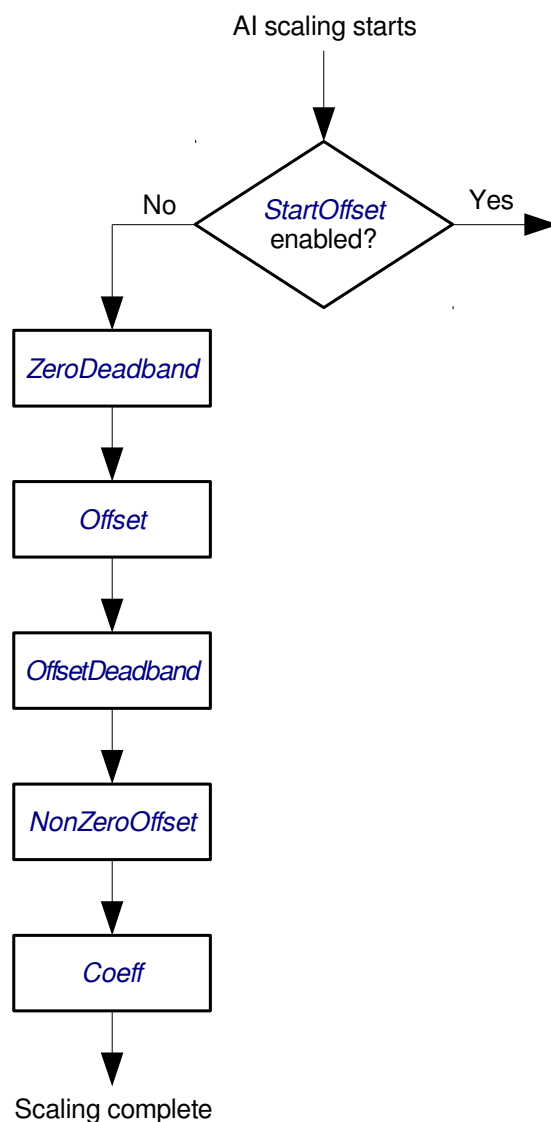


Figure 13.1 AI scaling without StartOffset enabled

Table 13.1 AI.ZeroDeadband processing sample

Value before	Value after (AI.ZeroDeadband = 2)
-10	-10
-2.1	-2.1
-2	0
-1	0
0	0
1	0
2	0
2.1	2.1
10	10

Table 13.2 AI.Offset processing sample

Value before	Value after (AI.Offset = 5)
-10	-5
-2	3
-1	4
0	5
1	6
2	7
10	15

Table 13.3 AI.OffsetDeadband processing sample

Value before	Value after (AI.OffsetDeadband = 2)
-10	-10
-2.1	-2.1
-2	0
-1	0
0	0
1	0
2	0
2.1	2.1
10	10

Table 13.4 AI.NonZeroOffset processing sample

Value before	Value after (AI.NonZeroOffset = 5)
-10	-15
-2	-7
-1	-6
0	0
1	6
2	7
10	15

Table 13.5 AI.Coeff processing sample

Value before	Value after (AI.Coeff = 2.5)
-10	-25
-2	-5
-1	-2.5
0	0
1	2.5
2	5
10	25

13.1.2 AI scaling with StartOffset enabled

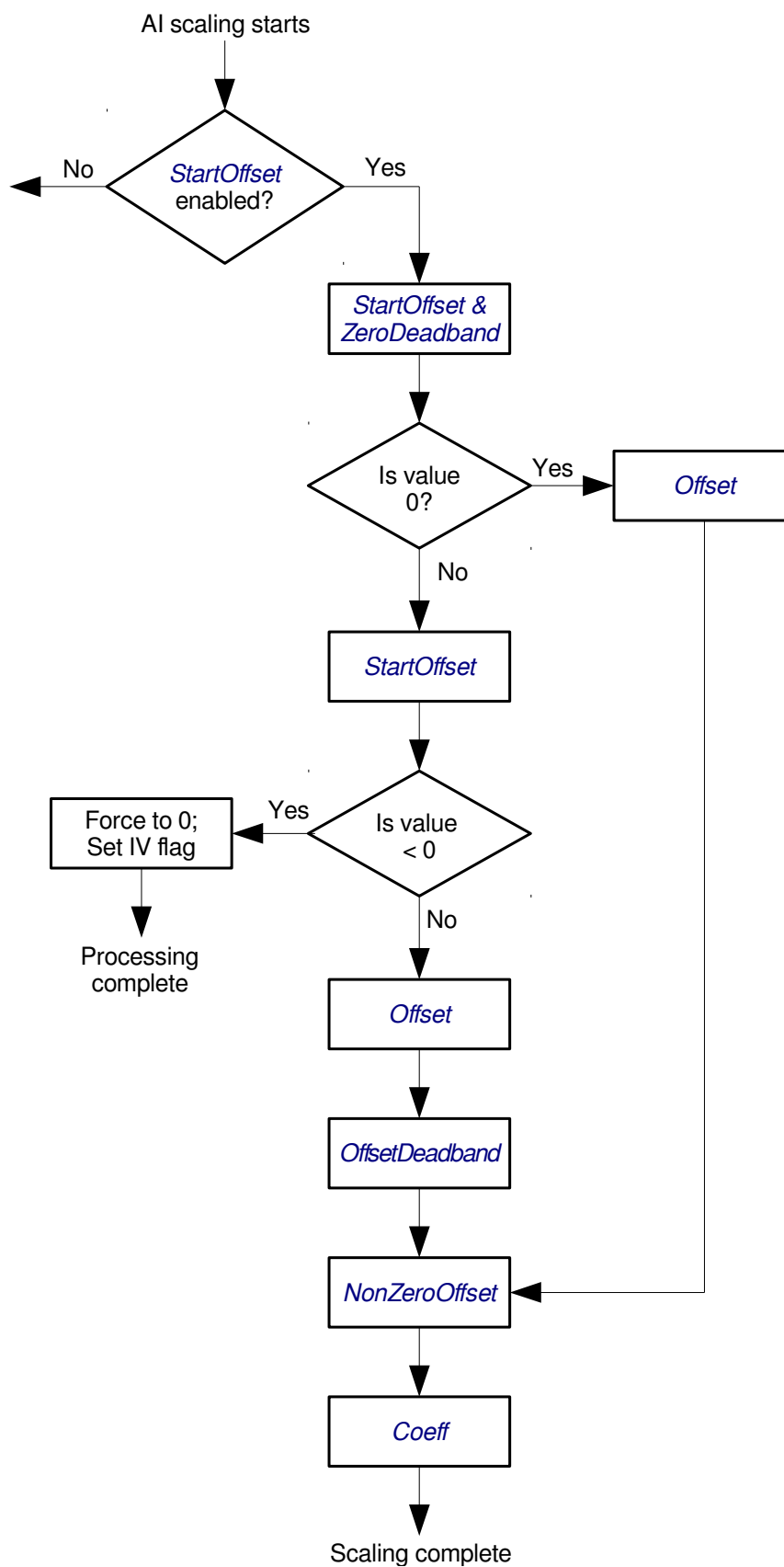
Flowchart on the right shows scaling sequence when leandc receives AI value from outstation or before sending AI value to upstream station depending on used communication protocol. Scaling sequence shown below is used if **StartOffset is enabled** (attribute [AI.StartOffset](#) > 0). Sample values before and after each step are listed in the following tables. Please note there is no relation between values shown in different tables. Tables are used to illustrate functionality of each step separately not the complete operation of the scaling sequence.

Table 13.6 AI.ZeroDeadband processing sample

Value before	Value after (AI.StartOffset = 6554) (AI.ZeroDeadband = 1)
-6556	-6556
-6555	0
-6554	0
-6553	0
-6552	0 & Invalid [IV]
-1	0 & Invalid [IV]
0	0 & Invalid [IV]
1	0 & Invalid [IV]
6552	0 & Invalid [IV]
6553	0
6554	0
6555	0
6556	6556

Table 13.7 AI.StartOffset processing sample

Value before	Value after (AI.StartOffset = 6554)
-32767	-26213
-6555	-1
-6554	0
-6553	0 & Invalid [IV]
-1	0 & Invalid [IV]
0	0 & Invalid [IV]
1	0 & Invalid [IV]
6553	0 & Invalid [IV]
6554	0
6555	1
32767	26213

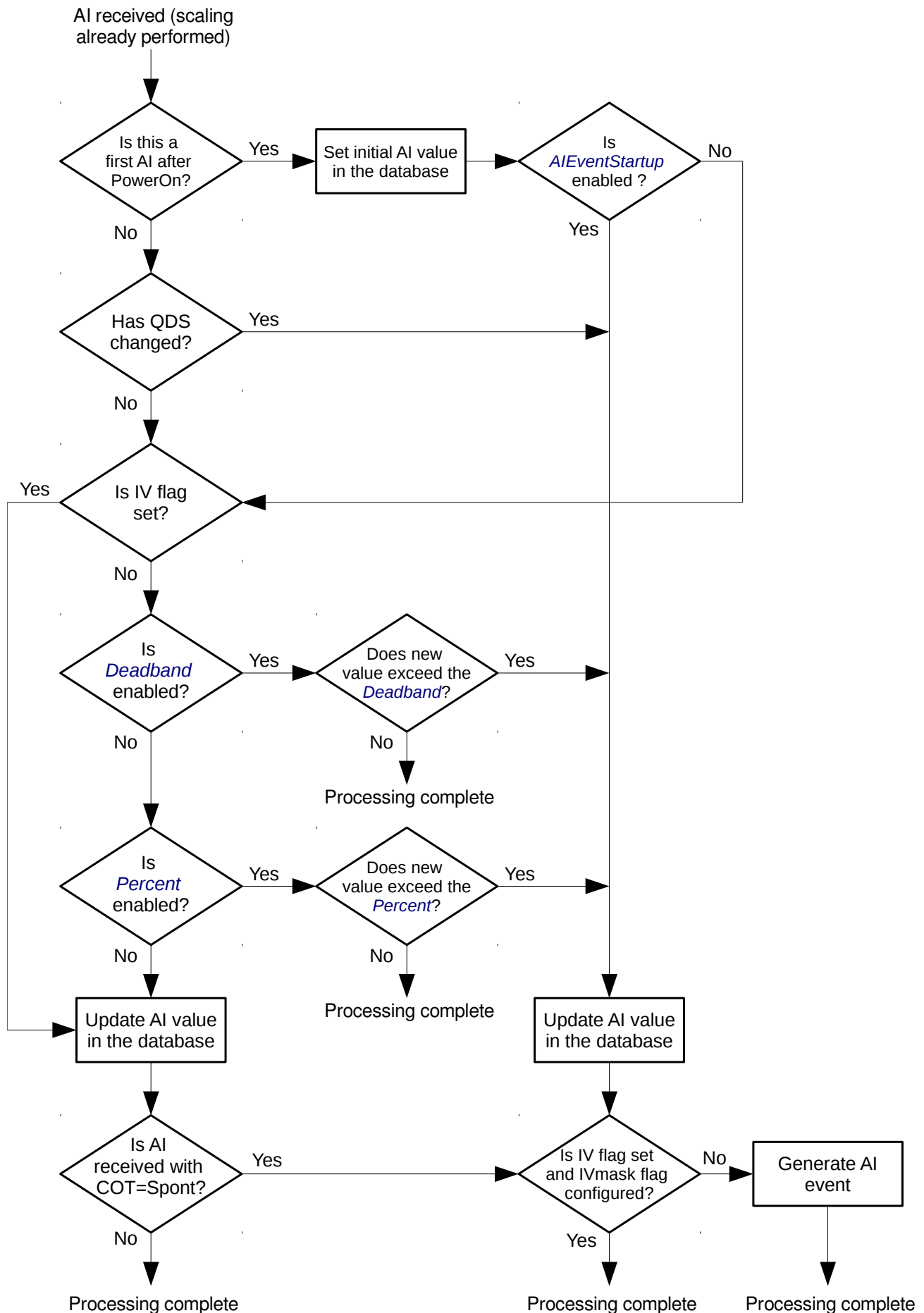
Figure 13.2 AI scaling with *StartOffset* enabled

13.1.3 Received AI processing

Flowchart below shows AI value processing when IEC 60870-5-101/103/104 Master protocol instance receives AI object from outstation. This processing takes place after AI scaling has been completed, refer to previous annexes for additional information on AI scaling.

The figure below shows how a real time value received from outstation will be processed if [AI.Deadband](#) attribute is enabled. Internal database will be updated and AI event will get generated every time a real time value exceeds 'static deadband'. Thresholds of the 'static deadband' are calculated based on previous value stored in the database. Attribute [AI.Deadband](#) = 2 is used as an example.

The figure below shows how a real time value received from outstation will be processed if [AI.Percent](#) attribute is enabled. Internal database will be updated and AI event will get generated every time a real time value exceeds 'dynamic deadband'. Thresholds of the 'dynamic deadband' are calculated based on previous value stored in the database. Attribute [AI.Percent](#) = 20 is used as an example.



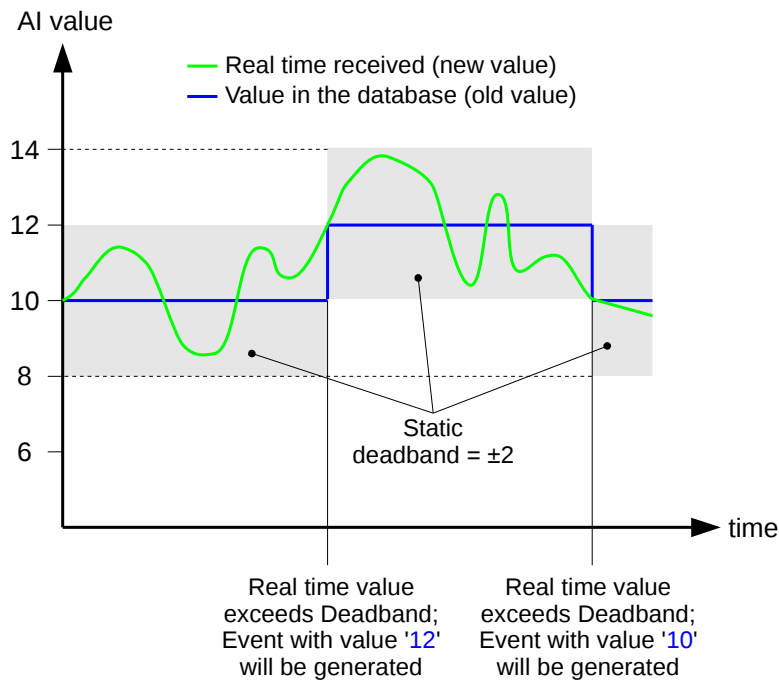


Figure 13.4 AI.Deadband processing sample

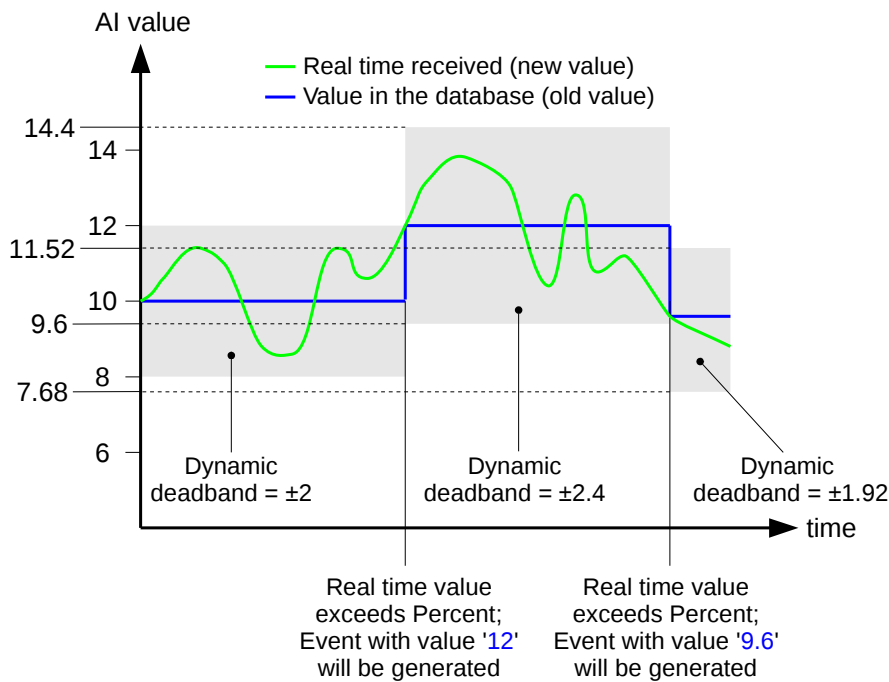


Figure 13.5 AI.Percent processing sample

13.1.4 0-20mA transducers

AIMs use 16bit Signed Integer variables for analogue value reporting. Lowest integer value 0 represents 0mA at AIM's input and the highest integer value 32767 represents 20mA at AIM's input.

Following formulas allow Integer value evaluation from Current at the AIM's input and vice versa.

Formula for evaluating current mA value is:

$$mA = \frac{Integer}{32767} * 20$$

example

$$\frac{2000}{32767} * 20 = 1.2207mA$$

Formula for evaluating Integer value is:

$$Integer = \frac{mA}{20} * 32767$$

example

$$\frac{2.2}{20} * 32767 = 3604$$

Sample values are summarized in the table [13.8](#) below and it is assumed **1A/0-20mA** current transducer is connected to the AIM. Current values at the transducer input are listed in the third column.

Table 13.8 AI sample values if 0-20mA input range is used

mA value	Integer value	Current at (1A) transducer input
0mA	0	0A
1mA	1638	0.05A
2mA	3277	0.1A
3mA	4915	0.15A
4mA	6553	0.2A
5mA	8192	0.25A
8mA	13107	0.4A
12mA	19660	0.6A
16mA	26214	0.8A
20mA	32767	1A

13.1.5 4-20mA transducers

It is common to use 4-20mA output range transducers as there is an option of detecting transducer failure if current at the AIM input drops below 4mA. However additional calculation is required to compensate the 4mA offset at the AIM input created because of this increased functionality.

AIMs will still use 16bit Signed Integer variables for analogue value reporting, but unlike the previous paragraph, full range can't be used and the 4mA offset needs to be taken into consideration. There is an option to automatically adjust 4mA offset and it can be enabled by setting Bit [0] of the Slave AI internal qualifier (attribute [AI.qualifier](#) please refer to the table [5.6](#)). Setting Bit[0] to '1' will enables automatic adjustment by subtracting 6554 from the received Integer value.

Offset 6554 is equal to 4mA current value (as per table [13.8](#) above) which means after subtraction Integer will be 0 when there are 4mA at AIM's input and Integer will be **26213** when there are 20mA at AIM's input.

Tip:

Leandc unit will report Integer '0' with Invalid [IV] flag set if the current at AIM input is less than 4mA (Integer is less than '6554'). This is an extended functionality for detecting transducer failure.

Following formulas allow Integer value evaluation from Current at the AIM's input and vice versa.

Formula for evaluating current mA value is:

$$mA = \left(\frac{Integer}{26213} * 16 \right) + 4$$

example

$$\left(\frac{2000}{26213} * 16 \right) + 4 = 5.2208mA$$

Formula for evaluating Integer value is:

$$Integer = \frac{(mA - 4)}{16} * 26213$$

example

$$\frac{(5.2 - 4)}{16} * 26213 = 1966$$

Sample values are listed in the table [13.9](#) below, those are calculated assuming **1A/4-20mA** current transducer is connected to the AIM. Current values at the transducer input are listed in the third column.

Table 13.9 AI sample values if 4-20mA input range is used

mA value	Integer value	Current at (1A) transducer input
0mA	0 & INVALID	Transducer not connected
1mA	0 & INVALID	Transducer not connected
4mA	0	0A
5mA	1638	0.0625A
6mA	3276	0.125A
7mA	4914	0.1875A
8mA	6553	0.25A
12mA	13106	0.5A
16mA	19660	0.75A
20mA	26213	1A

13.1.6 Special transducers

There are specific types of transducers that have offset at their input and this paragraph explains how to configure LEANDC unit to compensate measurement offset created by such transducers. A specific voltage transducer with input range 75-125V and output 4-20mA will be used as an example. Now in addition to the fixed 4mA output offset compensation described in the previous paragraph, there is another offset required to compensate 75V voltage offset at the transducer's input. Both offset compensation adjustment requires 3 separate steps as follow:

- 4mA compensation can be enabled by setting Bit [0] of the Slave AI internal qualifier attribute AI.qualifier as described in the previous paragraph. After 6554 offset subtraction Integer will be 0 when there are 4mA at AIM's input and Integer will be 26213 when there are 20mA the same as before.
- It is necessary to select a deadband to filter a noise around 4mA using AI.ZeroDeadband attribute. The AI.ZeroDeadband attribute has to be selected carefully to ensure a value exceeding the deadband is valid measurement (not a noise) and represents voltage above 75V at transducer's input. AI value fluctuations around 4mA that doesn't exceed deadband configured in the AI.ZeroDeadband attribute will be forced to 0.
- The final step is to compensate a 75V offset at transducer's input using AI.NonZeroOffset attribute. Please note AI.NonZeroOffset will be applied only to Integer values exceeding AI.ZeroDeadband. It is necessary to calculate an integer offset that is proportional to 75V. The following formula can be used, divide scaled Integer range (26213, after 4mA offset compensation) by actual transducer input range (75-125V, actual range after subtracting 75 is 50) and multiply by offset at the transducer's input (75V).

$$IntegerOffset = \frac{Integerrange}{inputrange} * inputoffset$$

example

$$\frac{26213}{50} * 75 = 39320$$

The proportional Integer offset is **39320** and following formulas can be used to evaluate Integer value from Current at the AIM's input and vice versa.

Formula for evaluating Current mA value from Integer is:

$$mA = \left(\frac{(Integer - 39320)}{26213} * 16 \right) + 4$$

example

$$\left(\frac{(40000 - 39320)}{26213} * 16 \right) + 4 = 4.415mA$$

Formula for evaluating Integer from Current mA is:

$$Integer = \left(\frac{(mA - 4)}{16} * 26213 \right) + 39320$$

example

$$\left(\frac{(5.7 - 4)}{16} * 26213 \right) + 39320 = 42105$$

Formula for evaluating Current mA value from Voltage is:

$$mA = \left(\frac{(Voltage - 75)}{50} * 16 \right) + 4$$

example

$$\left(\frac{(79.3 - 75)}{50} * 16 \right) + 4 = 5.376mA$$

13.1. Analog value processing

Formula for evaluating Integer from Voltage is:

$$Integer = \left(\frac{(Voltage - 75)}{50} * 26213 \right) + 39320$$

example

$$\left(\frac{(82.4 - 75)}{50} * 26213 \right) + 39320 = 43200$$

Following formulas allow Voltage evaluation from Current at the AIM's input or Integer.

Formula for evaluating Voltage from Integer is:

$$Voltage = \left(\frac{(Integer - 39320)}{26213} * 50 \right) + 75$$

example

$$\left(\frac{(40200 - 39320)}{26213} * 50 \right) + 75 = 76.678V$$

Formula for evaluating Voltage from Current mA is:

$$Voltage = \left(\frac{(mA - 4)}{16} * 50 \right) + 75$$

example

$$\left(\frac{(5.9 - 4)}{16} * 50 \right) + 75 = 80.936V$$

Sample values at various conversion stages based on **75-125V/4-20mA** voltage transducer are summarized in the table [13.10](#) below. Integer values after 4mA offset subtraction are listed in column 2. [AI.ZeroDeadband](#) attribute value of 2 is used for this example resulting Integer values 1 and 2 being forced to 0, functionality is shown in column 3. Integer values after [AI.NonZeroOffset](#) adjustment are listed in the column 4. Voltage values at the transducer input are listed in the column 5.

Table 13.10 AI sample values if 75-125V/4-20mA transducer is used

mA value	Integer value before 75V offset	ZeroDeadband active	Integer value after 75V offset	Voltage at (75-125V) transducer Input
0mA	0 & INVALID	No	0 & INVALID	Transducer not connected
1mA	0 & INVALID	No	0 & INVALID	Transducer not connected
4mA	0	No	0	0V...75V
4.0006mA	1	Yes, forcing to 0	0	75.002V
4.0012mA	2	Yes, forcing to 0	0	75.004V
4.0018mA	3	No	39323	75.006V
5mA	1638	No	40958	78.125V
6mA	3276	No	42596	81.25V
7mA	4914	No	44234	84.375V
8mA	6553	No	45873	87.5V
12mA	13106	No	52426	100V
16mA	19660	No	58980	112.5V
20mA	26213	No	65533	125V

13.2 Time Zone specification

It is possible to adjust incoming and outgoing message timestamps in case if LEANDC unit communicates to the peer station that uses a different time zone. Conventionally timezone and DST information is kept in the so-called 'Time Zone Database' that consists of a set of TZ format files, these are published and maintained by the Internet Assigned Numbers Authority (IANA), please refer to their website (<http://www.iana.org/time-zones>) for more information. In general there is a TZ file for each country in the world where information related to DST and other time adjustments is recorded. These files can be found in LEANDC unit operating system directory:

`/usr/share/zoneinfo`

leandc firmware will attempt to locate a TZ file matching the name specified in a `TimeZone` attribute in this system folder. If a matching file is not found, leandc firmware will use System default time zone which means the timestamps for the particular communication protocol instance will not be adjusted. Please find the list of most commonly used time zones below:

```
<TimeZone>UTC</TimeZone>
<TimeZone>Europe/Riga</TimeZone>
<TimeZone>Europe/London</TimeZone>
```

If required the System default time zone can be changed as described in Leandc_SSH manual section '*Change Leandc operating system time zone*'. The System default time zone is used for maintaining internal time of the LEANDC unit. Internal time is used for time synchronization, time-stamping logfile records, creating logfile names, etc.

Document version control

This manual was originally published with following leandc firmware.

Table 14.1 Compatibility with leandc firmware

Firmware Revision	Date
3.05	2014-11-28 11:39:37

Tip:

Use argument -v to check firmware revision and build date: `./leandc -v`

Table 14.2 Document version control

Version	Date	By	Comments
V1	17/08/2012	AK	Initial version
V2	03/10/2012	AK	New features added, changes in DI and AI Event attribute configuration
V3	13/11/2012	AK	Minor changes to DO object address sequence, new DO execution policy added
V4	03/12/2012	AK	AI value offset for 4mA transducer input compensation added to Slave protocol instances
V5	01/03/2013	AK	Range and Automatic configuration features added; GlobalTimeSync now available; changes to logfile specification
V6	13/03/2013	AK	HourLimit attribute description added; AI offset, AI zero deadband and 75-125 input transducer offset compensation added
V7	12/04/2013	AK	Minor formatting corrections; Appendix A – Analogue value processing added
V8	14/05/2013	AK	Automatic DI and AI object sorting for 'Master' and DO object sorting for 'Slave' communication protocol instances; SummerTime flag configuration added; Communication Status reporting address for Auto-configuration mode added; CommsFlags attribute added; Service DO commands added;
V9	21/05/2013	AK	SpeedUpStarted configuration option added

Continued on next page

Table 14.2 – continued from previous page

Version	Date	By	Comments
V10	01/06/2013	AK	Timezone configuration option added
V11	10/06/2013	AK	Offline reporting delay timer added
V12	18/11/2013	AK	<p>IEC60870-5-103 Master added;</p> <p>Unique names for communication protocol instance nodes under CommunicationCfg node;</p> <p>Link layer and common address of ASDU (CAA) now configured using attributes in communication protocol instance nodes;</p> <p>CommsFlags attribute created for Master communication protocol instances;</p> <p>DIEventType and AIEventType nodes created for Slave communication protocol instances;</p> <p>SpeedUpStarted node removed;</p> <p>Time-tagged command support added for IEC60870-5-104 Slave and new CommandLatency node created;</p> <p>DI/AI/DO qualifier attributes are optional from now on;</p> <p>DI/AI/DO TypeID attributes created;</p> <p>OffIndex attribute added to Slave communication protocol instance DO object nodes allowing to link 'On' and 'Off' commands to separate DO objects;</p> <p>Auto-configuration temporary disabled;</p> <p>GlobalQOC node added for Master communication protocol instances;</p> <p>Event logfile configuration moved to lelogger.xml file;</p> <p>HWLOG and HWEVENTLOG nodes created allowing to enable event logging for all communication protocol instances sharing the same hardware interface;</p> <p>Static and Event DI/AI information recording to event logfiles added;</p> <p>Slave communication protocol instance AI processing sequence flowcharts added;</p>
Continued on next page			

Table 14.2 – continued from previous page

Version	Date	By	Comments
V13	18/12/2013	AK	<p>Multiple IEC101sl communication protocol instances can share the same serial interface;</p> <p>OfflineDelay for IEC101sl communication protocol instance added;</p> <p>Setpoint command configuration added;</p> <p>GlobalDOType and GlobalAOType nodes added for Master communication protocol instances;</p> <p>IgnoreTimetags node added for Master communication protocol instances;</p> <p>New bit in DO/AO qualifier now enables option to accept only Direct-Execute commands;</p> <p>DO command invert option added, enabled by setting bit[1] in Slave and Master DO.qualifier;</p> <p>Master communication protocol instance AI processing sequence flowcharts added;</p>
V14	18/01/2014	AK	Version control element node added
V15	26/02/2014	AK	<p>Order of communication protocol instance definition corrected;</p> <p>UART TxDelay sample value table added;</p> <p>UART CtrlRdTimer and CtrlRdDebounce attributes created;</p> <p>ACDAways and FCBMaskLinkReq attributes created for IEC60870-5-101 Slave protocol;</p> <p>CommsFlags attribute added for Slave protocol instances;</p> <p>OfflineDelay default value of the IEC60870-5-101 Master protocol corrected, must be 0 and OfflineDelay element for IEC60870-5-104 Slave protocol created;</p> <p>DegradedRetries; DegradedTimeout and LinkOnlineDelay nodes added to IEC60870-5-101 and IEC60870-5-103 Master protocols;</p> <p>GlobalGI; AIDeadband and AIPercent nodes added to Master protocol instances;</p> <p>Master protocol instance nodes GlobalQOC; GlobalDOType and GlobalAOType nodes are renamed to DOQOC; DOType and AOType respectively;</p> <p>Bit[5] removed from Master protocol instance DO qualifier, use DOType element or individual DO object TypeID attributes for outgoing command ASDU Type selection;</p> <p>Ignore individual Time tag bit created for Master protocol DI/AI qualifier attributes;</p> <p>Name attributes added to all nodes;</p> <p>New Service DI (-5) created allowing to monitor status of the UART Ring Indicator RI pin(9);</p> <p>New Service DO (-5) created allowing to send Reset command to downstream outstation;</p>
Continued on next page			

Table 14.2 – continued from previous page

Version	Date	By	Comments
V16	31/03/2014	AK	<p>Supervision functionality added;</p> <p>UART Timeout; TxDelay and CtrlRdTimeout ranges changed;</p> <p>UART DataBits; StopBits and TxDelay attributes are no longer mandatory;</p> <p>Socket node name changed from IPv4 to TCPSERVER and TCPCLIENT and related Mode and Type attributes removed;</p> <p>New UDP socket node created;</p> <p>Socket IPport attribute name changed to Port;</p> <p>New socket attributes ConnectTimeout; Timeout; TxDelay and IdleTimeout created;</p> <p>IEC60870-5-101 master and slave protocol instances can now be linked to TCPSERVER; TCPCLIENT and UDP socket nodes;</p> <p>Multiple IEC60870-5-104 master protocol instances can now be linked to the same TCPCLIENT socket node;</p> <p>Bit[3] added to CommsFlags attribute to select either accept or reject new incoming connection to TCP server if linked protocol instance is already connected;</p> <p>TxAllVarLength node added for IEC60870-5-101 master and slave protocols;</p> <p>IEC60870-5-104 master OfflineDelay node can have value 0 now and default value changed to 6sec;</p> <p>Description of the logger LogFlags attribute Bit[4] updated to include IEC60870-5-101 link layer status information recording</p>
V17	08/04/2014	AK	<p>Automatic IEC60870-5-101/4 Slave protocol configuration re-enabled;</p> <p>Source attribute created for IEC60870-5-101/4 Slave protocols and Device attribute in DI/AI/DO/AO object elements is no longer mandatory;</p> <p>GIStartupDelay element created for IEC60870-5-101/4 Slave protocols;</p> <p>Bit[4] removed from Slave DI qualifier attribute;</p> <p>AI StartOffset and OffsetDeadband attributes created for IEC60870-5-101/4 Slave AI objects;</p> <p>Bits[5...6] removed from Slave AI qualifier attribute;</p> <p>AIEventStartup element created for IEC60870-5-101/3/4 Master protocols;</p> <p>AI StartOffset; ZeroDeadband; Offset; OffsetDeadband and NonZeroOffset attributes created for IEC60870-5-101/3/4 Master AI objects;</p>
Continued on next page			

Table 14.2 – continued from previous page

Version	Date	By	Comments
V18	28/05/2014	AK	<p>Multiple ASDU configuration concept using station identifier StationID attribute, which has been added to IEC104sl and IEC104ma element nodes. Existing LinkAddr attribute is used as station identifier for IEC101sl; IEC101ma and IEC103ma element nodes.</p> <p>All ASDUAddr attributes removed from individual DI/AI/DO/AO nodes;</p> <p>New concept of protocol setting node element migration to attributes begins with this firmware release; First protocol element nodes to contain setting attributes are: XMLSettings; CommsSettings; ASDUFlags; Broadcast and Periodic;</p> <p>Information address sequence check across object types introduced. It is essential to use new attribute IOAOverlap if the same information addresses are being reused for DI/AI/DO/AO objects. IOAOverlap is attribute of the newly created XMLSettings element node;</p> <p>IEC60870-5-101/4 Slave protocol configuration StartupGIDelay element migrated to become an attribute of the newly created CommsSettings element node;</p> <p>TranspTypes attribute created for IEC60870-5-101/4 Slave protocol configuration;</p> <p>IEC60870-5-101/4 Master protocol configuration OnlineGIDelay element migrated to become an attribute of the newly created CommsSettings element node;</p> <p>New option to send General Interrogation using broadcast Common address of ASDU can be configured using GI attribute in IEC60870-5-101/4 Broadcast element node;</p> <p>IEC60870-5-101/4 Master protocol configuration GlobalTimeSync element migrated to become an attribute TimeSync of the newly created Broadcast element node;</p> <p>IEC60870-5-101/4 Master protocol configuration periodic GIInterval; Group1Interval... Group16Interval; TimeSyncInterval elements migrated to become attributes GI; Group1... Group16; TimeSync respectively of the newly created Periodic element node;</p> <p>Default values of DIEventBuffSize and AIEventBuffSize elements are automatically initialized to twice the amount of configured objects, instead of fixed value 1024 as used to before;</p>
			Continued on next page

Table 14.2 – continued from previous page

Version	Date	By	Comments
V19	26/06/2014	AK	<p>All protocol setting node elements migrated to attributes; New option to mark DI/AI objects with NT bit when outstation goes offline or is disabled using service command. IEC60870-5-101/4 Master protocol attributes OfflineNTDelay and DisabledNT; Option to send valid AIEVs to SCADA system on leandc startup in order to initialize the state of legacy spontaneous-only AIEVs. Valid AIEVs with 0 value will be sent after a number of seconds specified in LegacyAIEVinitdelay attribute on system startup in order to initialize SCADA database and make it ready to receive first legacy AIEV. StationID attribute added to IEC104Csl node; TypeID attribute added to IEC60870-5-101/4 Master DI/AI objects; SingleCharACK attribute added for IEC60870-5-101 Slave protocol allowing to respond with single character (0xE5 or 0xA2) ACK or NACK messages</p>
V20	09/10/2014	AK	<p>DIEventStartup attribute added to IEC60870-5-101/3/4 Master protocol configuration;</p>
V21	28/11/2014	AK	<p>Modbusma communication protocol instance added; Leandc XML configuration manual is HTML-based from now on;</p>

Contact us

Londelec UK Ltd
19 Marlborough road
Banbury
OX16 5DB
UK

Phone +44 (0) 207 060 7087
info@londelec.com